FREDERICK COUNTY
ASSESSMENT OF CONTROLS:
PETER PAN RUN MONITORING
JULY 2019 - JUNE 2020

Prepared for

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1.0 INTRODUCTION

1.1 REGULATORY REQUIREMENT

The performance of long-term monitoring in Peter Pan Run fulfills requirements specified in Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit No. 11-DP-3321, MD0068357. This third-generation Phase I NPDES MS4 permit, which took effect December 30, 2014 and covers stormwater discharges from the municipal separate storm sewer system in Frederick County, was in force during this reporting period (July 1, 2019 – June 30, 2020). Frederick County ended its existing permit on December 29, 2019 in compliance. All monitoring efforts performed in the third-generation permit have been administratively extended, including the monitoring at Peter Pan Run, until a new MS4 Permit is executed. This monitoring report documents the monitoring activities at Peter Pan Run to meet requirements under the MS4 permit.

The Peter Pan Run monitoring meet's Frederick County's NPDES MS4 permit obligations under Part IV, Standard Permit Conditions, Subpart F, Assessment of Controls. Specifically, the monitoring meets IV.F.1 – Watershed Restoration Assessment, as the watershed is monitored before and after the retrofit of several stormwater management ponds in the study drainage area to detect changes over time in water quality and channel stability. Further, the monitoring satisfies permit section IV.F.2 – Stormwater Management Assessment, as changes in condition have been monitored over time as the drainage area was developed. The monitoring program in Peter Pan Run was designed to build a long-term database (currently 1999 to 2020) of water quality and biological conditions and to assess the cumulative effects of both stormwater runoff stemming from development and the application of restoration projects in the watershed.

1.2 DESCRIPTION OF STUDY AREA

With approval from the Maryland Department of the Environment (MDE), the County selected Peter Pan Run as the study stream to assess the effect of the construction of The Villages of Urbana planned unit development (PUD) within the headwaters on the stream's chemical, physical, and biological functions. Peter Pan Run is located within the Bush Creek watershed, which flows westward into the Monocacy River near Frederick Junction.

The Villages of Urbana is a mixed-use development consisting of 3,500 residential units, along with substantial commercial and office space. Initial construction activities within the PUD began in early 1999, with major construction activities beginning in August of that year. Estimates in the County's regional plan (FCDPZ 2004) indicated that between 200 and 300 new residential lots would be recorded each year in the Urbana PUD, accounting for most of the expected growth within the Urbana Planning Region through 2010. During fiscal year (FY) 2020, construction of the PUD is complete with all sections occupied by residents. Washington Square at Villages of Urbana, located along Urbana Pike, was the last residential section that was completed in 2019. No new commercial development occurred during the fiscal year in the PUD. Figure 1-1 and 1-2 provide a series of aerial photographs illustrating changes in land use that have occurred within the catchment of Peter Pan Run over the course of the PUD's development.

1.3 LONG-TERM MONITORING PLAN

In May 1999, the County initiated a long-term monitoring program for the Peter Pan Run study area to establish baseline, pre-construction conditions in the catchment and subsequently to monitor conditions as development progresses within the Peter Pan Run watershed in order to assess potential long-term impacts associated with the new land use. The program involves monitoring flow volumes and water quality from both instream and SWM pond outfall stations, as well as collecting physical and biological data from four permanent stream monitoring stations on the mainstem and its tributaries (Figure 1-2). In particular, monitoring is focused on the long-term problems commonly associated with residential development, which could occur within Peter Pan Run. These potential problems include sedimentation and erosion resulting from increased runoff from impervious surfaces, pollutant runoff from roads and parking lots, elevated nutrient loading caused by the application of lawn fertilizers, and the illegal disposal of oil and other household chemicals via storm drains.

Frederick County has compiled data to characterize the catchment upstream of the Peter Pan Run instream monitoring station and the Pond-R (BMP NPDES # 199FR) outfall station. Data on catchment area, land uses, and station location are provided in the geodatabase that comprises the County's Annual Report submittal. Land use was derived from 2010 Maryland Department of Planning GIS data, which is the most recent data available. At present, the County's SWM database indicates that 89 structural SWM facilities (22 extended detention dry ponds, 27 extended detention wet ponds, 15 bioretentions, nine sand filters, five underground filters, four permeable pavements, two grass swales, two shallow marshes, one infiltration trench, one wet pond, and one bio-swale) have been constructed within the Peter Pan Run catchment area. These data will be updated in future years as needed.

In 2018, Frederick County began retrofitting 15 extended detention dry ponds to extended detention wet ponds or surface sand filters in the Peter Pan Run catchment area. Retrofits of all stormwater facilities were completed by the end of 2019 and are summarized in Table 1-1 below. Due to high infiltration rates at some retrofit sites, some of the intended designs from extended detention dry ponds to extended detention wet ponds have been modified to sand filters to achieve water quality benefits and are noted below in the table as such. As these retrofits become functional, this study will look to assess the impact of their performance in the Peter Pan Run catchment area.

Table 1-1. Pond retrofits completed within the Peter Pan Run catchment area						
Peter Pan Run Pond Retrofit Project Name	**REST BMP ID**	**REST BMP Type**	**BMP Class**	**# of BMPs**	**Impervious Acres Treated**	**Built Date**
Villages of Urbana, Sec. M - 5, Pond 'C' - Retrofit	FR17RST000077	PWED	S	1	14.53	1/9/2019
Villages of Urbana, Section M-10, SWM Pond 'R' - Retrofit	FR17RST000199	PWED	S	1	15.31	1/9/2019
Villages of Urbana, Village I, Pond B - Retrofit	FR17RST000060	PWED	S	1	9.05	1/9/2019
Villages of Urbana, Sec. M-8, Pond M1 - Retrofit	FR17RST000186	PWED	S	1	10.98	4/30/2019
Villages of Urbana, Section K4, Pond 'FF' - Retrofit	FR17RST000197	PWED	S	1	2.64	4/30/2019
Villages of Urbana, Village 1, Pond F - Retrofit	FR17RST000046	PWED	S	1	4.60	5/20/2019
Villages of Urbana, Sec. K - 2, Pond 'J' - Retrofit	FR17RST000078	PWED	S	1	11.28	6/1/2019
Villages of Urbana, Village V, Sec. K3, Pond "L" - Retrofit	FR17RST000039	PWED	S	1	7.10	6/1/2019
Urbana Highlands, Sec. P3 - SWM Pond 'PA' - Retrofit	FR17RST000928	PWED	S	1	15.98	8/22/2019
Urbana Highlands, Sec. P3 - SWM Pond 'PB' - Retrofit	FR17RST000922	PWED	S	1	20.56	8/22/2019
Urbana Highlands, Sec. P4 - SWM Pond 'PC' - Retrofit	FR17RST000924	FSND	S	1	4.68	8/22/2019
Villages of Urbana, Pond 'N' - Retrofit	FR17RST000663	PWED	S	1	6.04	10/25/2019
Villages of Urbana, SWM Pond A1 - Retrofit	FR17RST000662	PWED	S	1	4.44	10/25/2019
Villages of Urbana, SWM Pond 'S' - Retrofit	FR17RST000200	FSND	S	1	1.95	10/25/2019
Villages of Urbana, Village I, Pond G - Retrofit	FR17RST000047	PWED	S	1	4.94	10/25/2019

Monitoring activities within the study area were initially described in the County's *Long-Term Monitoring Plan for the Peter Pan Run Watershed, Frederick County, Maryland* (Southerland et al. 1999), which laid out methods for biological, physical, and water chemistry monitoring of the stream. To keep pace with the changing program needs and evolving science, Frederick County continues to make periodic revisions and improvements to its monitoring efforts, as documented in the County's NPDES Annual Reports. Two quality assurance/quality control documents have been developed for the County's monitoring efforts: *Quality Assurance Project Plan for Water Chemistry Monitoring in Peter Pan Run* (Drescher 2020), and *Quality Assurance Project Plan for Biological and Physical Monitoring in Peter Pan Run* (Drescher 2020).

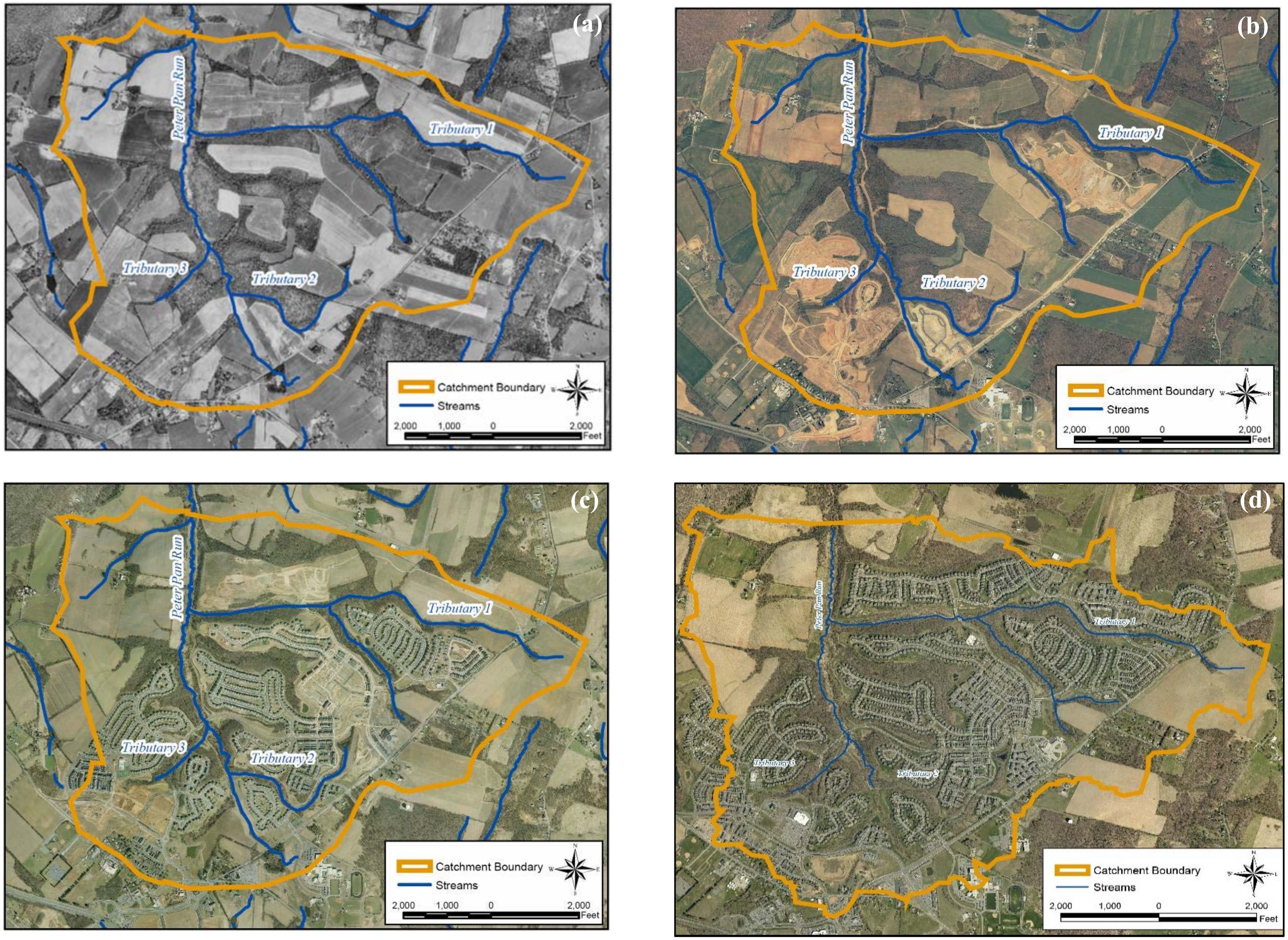

Figure 1-1. Aerial photographs of the Urbana Planned Unit Development (PUD) showing changes in the area over time. (a.) predevelopment conditions in April 1988 (Source: USGS), (b.) initial stages of development in March 2000 (Source: Frederick County), (c.) conditions in March-April 2005 (Source: Frederick County), and (d.) conditions in 2014 (Source: Frederick County).

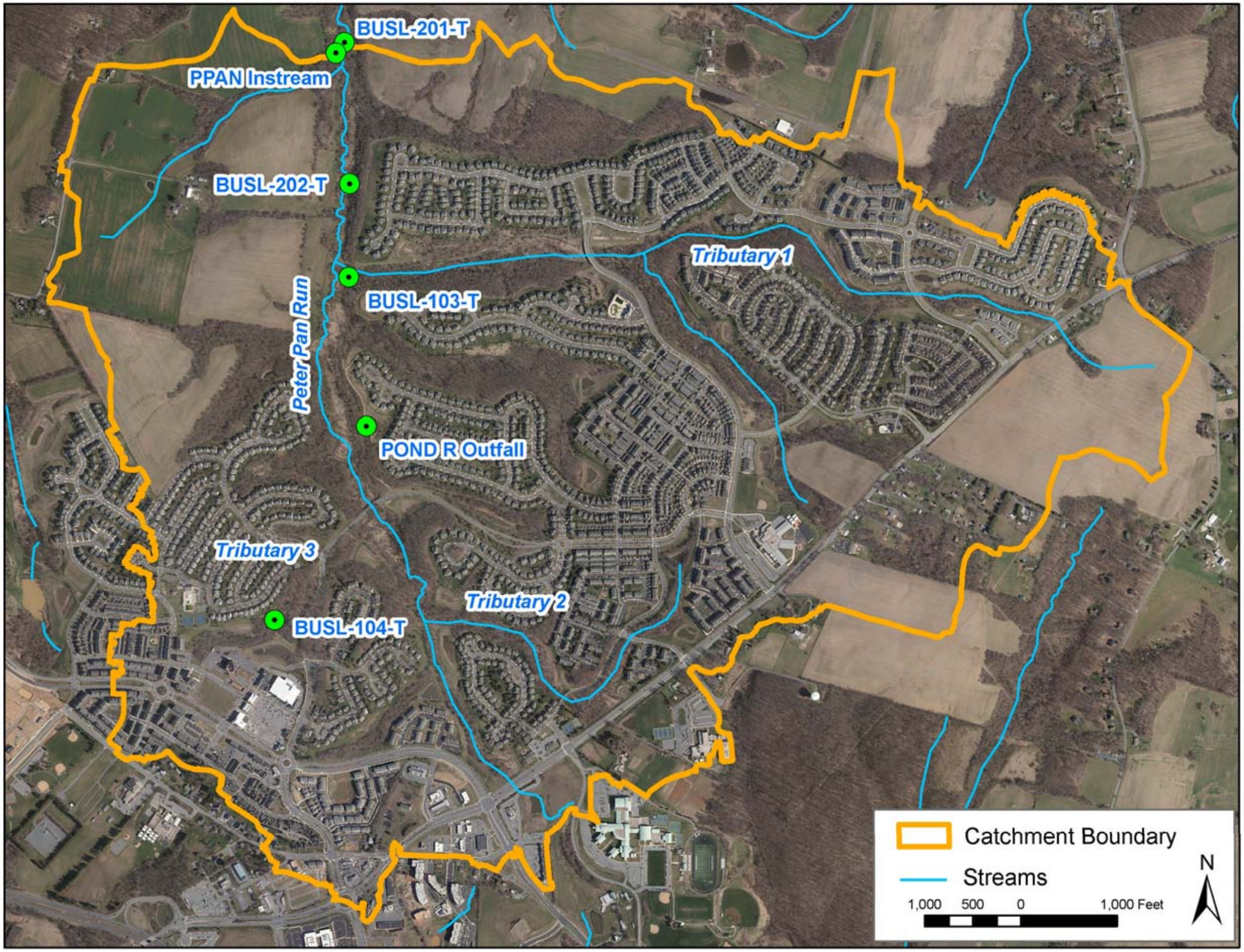

Figure 1-2. Annotated aerial photograph of Peter Pan Run in Lower Bush Creek watershed, Frederick County, Maryland showing the Peter Pan Run monitoring stations. (Image source: Maryland iMAP Image Service, 2017)

1.4 MONITORING METHODS

Currently, and as approved by Maryland Department of the Environment (MDE), the methodologies used to assess streams in Frederick County are comparable to that used by other counties in Maryland, which facilitates integration of Frederick County's monitoring efforts with those of state and other county programs. Methods for biological and physical stream assessments were developed by the Maryland Department of Natural Resources (DNR) for its Maryland Biological Stream Survey (MBSS), a statewide biological and physical habitat assessment program. MBSS methods (Stranko et al. 2019) are a regional application of EPA's Rapid Bioassessment Protocols (RBP, Plafkin et al. 1989, Barbour et al. 1999). Methods developed by Montgomery County Department of Environmental Protection were also employed from 1999 through 2006, in part, for quantitative physical habitat assessments. Beginning in 2007, it was determined that this additional dataset was not significantly adding to the understanding of stream conditions, and so use of the Montgomery County protocols was discontinued. In keeping with the sampling schedule established by these model programs, physical, biological, and water chemistry monitoring activities follow the annual schedules presented in Tables 1-2 and 1-3.

Table 1-2. Annual physical and biological sampling schedule for watershed monitoring stations

Spring (March through April)	**Summer** (June through September)
Physical habitat: • MBSS Spring Habitat assessment • Quantitative Geomorphologic assessment	Physical habitat: • MBSS Summer Habitat assessment
Ambient water quality: • dissolved oxygen, specific conductivity, pH, turbidity, and water temperature	Ambient water quality: • dissolved oxygen, specific conductivity, pH, turbidity, and water temperature
Biological monitoring: • benthic macroinvertebrate community	Biological monitoring: • fish community

Table 1-3. Annual stream chemistry sampling schedule for the instream and outfall stations

Baseflow (Monthly)	**Wet Weather** (up to 2 storms per quarter)
Chemical water quality: • dissolved oxygen, specific conductivity, pH, and water temperature • baseflow samples for laboratory analysis	Chemical water quality: • dissolved oxygen, specific conductivity, pH, and water temperature • storm samples for laboratory analysis

In 2017, the County made contractual changes in the responsible engineering firm from Versar to KCI Technologies (KCI) such that KCI assumed responsibility of the chemical, physical, and biological monitoring of the Peter Pan Run instream and SWM pond outfall stations. Frederick County invested heavily in upgrading the water quality monitoring equipment to ensure the permit monitoring requirements are met. These efforts included retiring old equipment and purchasing two ISCO automated samplers, one rain gauge, two flow modules, two solar panels, and two multi-parameter sondes.

2.0 MONITORING RESULTS AND DISCUSSION

2.1 CHEMICAL MONITORING

As specified in the County's MS4 permit, the County has established, and maintains, two long-term chemical stormwater monitoring stations within the Urbana PUD to characterize stormwater discharges from both a stormwater management pond outfall draining a specific land use (Pond-R; Figure 2-2a) and an associated in-stream station (PPAN-01; Figure 2-1).

In the beginning of FY2018, a change in contracted engineering firm occurred from Versar to KCI Technologies (KCI). In July 2017, Versar removed all equipment from the two stations and the County purchased new Teledyne ISCO equipment that was installed by KCI in October of 2017. KCI installed an ISCO 6712 automated sampler with an ISCO 730 Bubbler Flow Module at each station. A new tipping bucket rain gauge was installed at the POND-R station. Two new ISCO AQ 700 multi-parameter sondes were also purchased for deployment during sampled storm events at each station. Data collection with new equipment began on October 20, 2017.

<u>Peter Pan Run Instream Station</u>

Long-term chemical monitoring has continued at the Peter Pan Run instream monitoring station (located at PPAN-01) since May 1999. Photographs of the monitoring equipment as set up by KCI and related site features are presented in Figures 2-1, 2-2a, and 2-2b. In November 2018, KCI installed a PVC stilling well in a pool feature of Peter Pan Run to monitor water levels within the channel. Historically, water level data was collected in a riffle approximately 15 feet downstream of the stilling well.

Figure 2-1. Ambient instream monitoring station at Peter Pan Run in the Lower Bush Creek watershed, Frederick County, MD. The instream station includes sample intake tubing located near a stilling well at the center of the stream, a staff gauge and flow meter sensor against the left bank, and a "storm box" located in a clearing near the bank. Photograph taken November 24, 2018.

Land use immediately surrounding the Peter Pan Run instream station remains primarily agricultural; however, the completed Urbana PUD construction has occurred within approximately 500 yards of the station. The instream station is located on the west bank of Peter Pan Run. The station is bordered by agricultural fields to the immediate west and east with patches of densely forested and shrub areas along the stream and tributaries. A sanitary sewer pipeline (completed winter 1999/2000) runs parallel to the east side of the stream, extending the full length of Peter Pan Run, south to the Urbana PUD area. A branch sanitary sewer line extends eastward, along the north side of Tributary 1.

Outfall Station

Within the Urbana PUD, Pond-R (Figure 2-2a and 2-2b) was monitored as a land use-specific extended detention dry pond from December 2002 thru July 2018. Installation of water chemistry monitoring and automated sampling equipment was completed on December 24, 2002, removed in July 2017 by Versar, and new monitoring equipment purchased by Frederick County was reinstalled by KCI on October 16, 2017. Initial monitoring characterized water quality at the outfall of the basin during residential construction with the facility functioning as a sediment trap. Conversion of the Pond-R sediment trap to a functional dry pond began in approximately late March 2004 and concluded during the first week of July 2004. Active construction of the Pond-R retrofit conversion from a dry extended detention pond to a wet extended detention pond occurred from July 2017 to October 24, 2018. Storm monitoring efforts were deferred while the pond was undergoing construction and resumed in November 2018.

Figure 2-2a. Villages of Urbana "Pond-R" outfall water chemistry monitoring station and rain gauge. Photograph taken October 16, 2017.

Figure 2-2b. Bubbler flow module located at the midpoint of the Pond-R outfall pipe sampling stage data for the Pond-R station.

Land use upstream of Pond-R consists of medium-density residential housing comprising 30.4 acres (38.8%) of the total 78.4 acres of the Village VII section of the Urbana PUD.

2.1.1 Chemistry Monitoring Procedures

As part of the program, Frederick County conducted monthly baseflow monitoring at both the Peter Pan Run ambient instream (PPAN-01) and the Pond-R outfall (POND-R) stations beginning in FY2016 to develop a dry weather flow database. Baseflow monitoring included manual grab sampling with parameter-specific sampling bottles containing the appropriate preservative. Calibrated field instruments were used to measure basic physical water quality parameters (e.g., water temperature, dissolved oxygen, specific conductivity, and pH). Field notes and data were recorded on preprinted, project-specific field sheets. During weekly inspections of the monitoring stations, field teams checked equipment for proper operation and maintained equipment logs. Baseflow monitoring at the outfall station occurred only when flow was present since its conversion to an extended detention dry pond in July 2004. Baseflow was infrequent in 2016, was observed more frequently in FY2017, and was not observed at the Pond-R outfall through FY2018 to the present fiscal year.

Beginning in 2015, the MS4 permit required eight storms to be sampled per year; a new storm event frequency was implemented to capture two events per quarter. Bi-quarterly storm sampling of Peter Pan Run and Pond-R was performed using ISCO automated samplers and flow meters located at each water chemistry monitoring station (changed to stage meters in FY2018). Storm event monitoring at PPAN-01 and POND-R began in May 1999 and February 2003, respectively. For each storm, the equipment at each station was used to collect and prepare volume-weighted, composite samples that represent the rising, peak, and falling limbs of each storm hydrograph. Manual grab samples were collected for "first flush" parameters (oil and grease, total petroleum hydrocarbons (TPH), phenols, and fecal coliform) using dedicated bottles containing preservative. Starting in FY2018, TPH and e-coli were tested throughout the storm. In FY2019, TPH and e-coli were collected by the ISCO machines and not performed with manual grab samples. An electronic rain gauge located at the outfall station recorded rainfall data for calculation of rainfall totals and storm intensity and to determine storm event validity (i.e., rainfall quantity greater than 0.10"). At each station, the flow meter measured stage height and converted the value to a discharge rate. The replacement equipment installed in FY2018 measured stage height and discharge rate were calculated utilizing a rating table derived from field measured data at the instream station and Manning's equation at the outfall station. Field discharge measurements at the instream station were collected using the USGS' stream velocity profile measurement technique (USGS 1982), and updated, as needed. These continuous level, flow, and rainfall measurements were downloaded at least twice monthly.

Following NPDES permit guidelines, all baseflow and stormflow samples were analyzed for the parameters listed in Table 2-1. Samples were stored on ice until they could be transported under chain of custody to the laboratory. Sample analysis was performed by Martel Laboratories, Inc., of Towson, MD. Field and laboratory results from the monitored storms are discussed in the sections below.

Table 2-1. Parameters and detection limits for Frederick County's Water Chemistry Monitoring Program		
Parameter	**Detection Limit**	**Method**
Biochemical Oxygen Demand (BOD) (5-day)	2 – 4 mg/L	SM 5210 B
Total Kjeldahl Nitrogen (TKN)	0.2 mg/L	SM4500NH3-C
Nitrate and Nitrite	0.05 mg/L	SM 4500NO3-H
Total Phosphorus	0.01 mg/L	SM 4500P-E
Total Suspended Solids (TSS)	1 mg/L	SM 2540 D
Copper	2 µg/L	EPA 200.8
Lead	2 µg/L	EPA 200.8
Zinc	2 µg/L	EPA 200.8
Hardness	1000 µg/L	SM 2340C
Total Petroleum Hydrocarbons (TPH)	2.7 mg/L	EPA 1664
E. coli	1 MPN/100 mL	SM 9223B

2.1.2 Storm Information

KCI field staff successfully monitored nine storm events at the Peter Pan Run instream and Pond-R outfall stations during the sampling period September 30, 2019 through April 30, 2020. All FY2020 samples collected at the Pond-R outfall station reflect the post-retrofit condition. Baseflow monitoring was carried out at a monthly rate between July 2019 and June 2020 at the Peter Pan Run instream station accounting for twelve samples.

Challenges during the course of the reporting year included water quality sonde malfunctions and repairs for pH and temperature probes, stage height equipment damage at both sites and the stilling well pool filling in with sediment due to a large storm event that occurred on 7/8/2019, intermittent rain gauge malfunctions, the instream station icing over during the winter months, a drought that occurred during September and October of 2019 causing the Pond-R water level to drop resulting in no discharge from Pond-R for some sampled storms, and rodent infestations including mice chewing through bubbler and intake tubing at Pond-R.

As presented in Table 2-2, rainfall measured on site from sampled storms ranged in quantity from 0.42 to 1.76 inches during qualifying events, and in duration from 3.92 hours to 18.58 hours. Average rainfall intensities from sampled storms ranged from 0.04 to 0.19 inches per hour.

Table 2-2. Summary of storm events monitored in FY2020* at Peter Pan Run

Date	Start Time	Rainfall Duration (hrs)	Rainfall** (in)	Avg. Intensity (in/hr)	Storm as % of Total Rainfall for Month
9/30/2019	7:35	3.92	0.42	0.11	63%
10/16/2019	10:00	4.42	0.86	0.19	15%
10/27/2019	23:40	10.42	1.32	0.13	23%
11/23/2019	20:10	5.08	0.68	0.13	67%
12/1/2019	5:10	18.58	0.77	0.04	18%
1/25/2020	23:20	11.50	1.76	0.15	57%
3/19/2020	18:55	9.58	0.53	0.06	17%
4/13/2020	19:30	11.25	1.10	0.10	32%
4/30/2020	4:55	12.00	0.60	0.05	17%

* FY denotes "Fiscal Year," defined as July to June.
** For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station data.

Because variation in pollutant loads and even changes in channel geometry can result from variable weather and discharge patterns, an analysis is conducted to check the project rainfall measurements against other local datasets, and to determine the departure from normal or average conditions. Table 2-3 compares monthly rainfall totals recorded at the Peter Pan Run station to monthly data collected at a local National Oceanic and Atmospheric Administration (NOAA) weather monitoring station (NOAA 2019). The NOAA weather stations at Emmitsburg, MD and Clarksburg, MD are approximately 25 miles north and 6 miles south-southeast, respectively, of Urbana, MD. Rainfall amounts recorded during monitored storms are presented in Figure 2-3. Note that the project rain gauge was located at Peter Pan Run instream station until early 2003 when the rain gauge was relocated to the Pond-R outfall station.

For the twelve-month monitoring period in FY2020, total annual rainfall near the site, as recorded at NOAA's Clarksburg gauge (48.32 inches) was 20% above normal compared to the long-term annual average of 40.40 inches recorded in Frederick County (Figure 2-4). Total annual rainfall data was used from the NOAA Emmitsburg rainfall gauge from 1991 to 2007 and the NOAA Clarksburg rainfall gauge from WY 2007 to FY2020. Note that the Emmitsburg rainfall gauge was offline between July 2005 and July 2006, the June 2007 rainfall data were missing from the Emmitsburg station, and the September 2018 rainfall data were missing from the Clarksburg station. During FY2020, the in-situ rain gauge located at Pond-R recorded 43.09 inches between July 2019 and June 2020, 7% above the normal average depth in Frederick County for the same time period (Figure 2-5). Total discharge volume at the Peter Pan Run instream monitoring station between July 2019 and June 2020 was 57% lower than in the prior fiscal year (July 2018 – June 2019) (Figure 2-6b).

Table 2-3. FY2020 Rainfall data (totals by month; inches)					
Month	**In-situ ISCO[(a)]**	**Clarksburg[(b)]**	**Emmitsburg[(b)]**	**Normal[(c)]**	**In-situ Departure from Normal**
July-19	6.63	7.33	8.39	3.70	2.93
August-19	3.85	4.21	1.52	3.50	0.35
September-19	0.67	0.31	0.89	3.60	-2.93
October-19	5.70	7.09	6.04	3.10	2.60
November-19	1.01	1.31	2.85	3.30	-2.29
December-19	4.23	3.25	4.46	2.90	1.33
January-20	3.10	3.00	3.98	2.80	0.30
February-20	3.80	3.32	2.64	2.70	1.10
March-20	3.03	3.40	2.76	3.30	-0.27
April-20	3.43	5.81	3.89	3.30	0.13
May-20	1.06	1.84	4.06	4.30	-3.24
June-20	6.58	7.45	2.59	3.90	2.68

(a) For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station data.

(b) Clarksburg and Emmitsburg monthly rainfall data from National Oceanic and Atmospheric Administration.

(c) Based on Frederick County regional long-term rainfall data from National Oceanic and Atmospheric Administration.

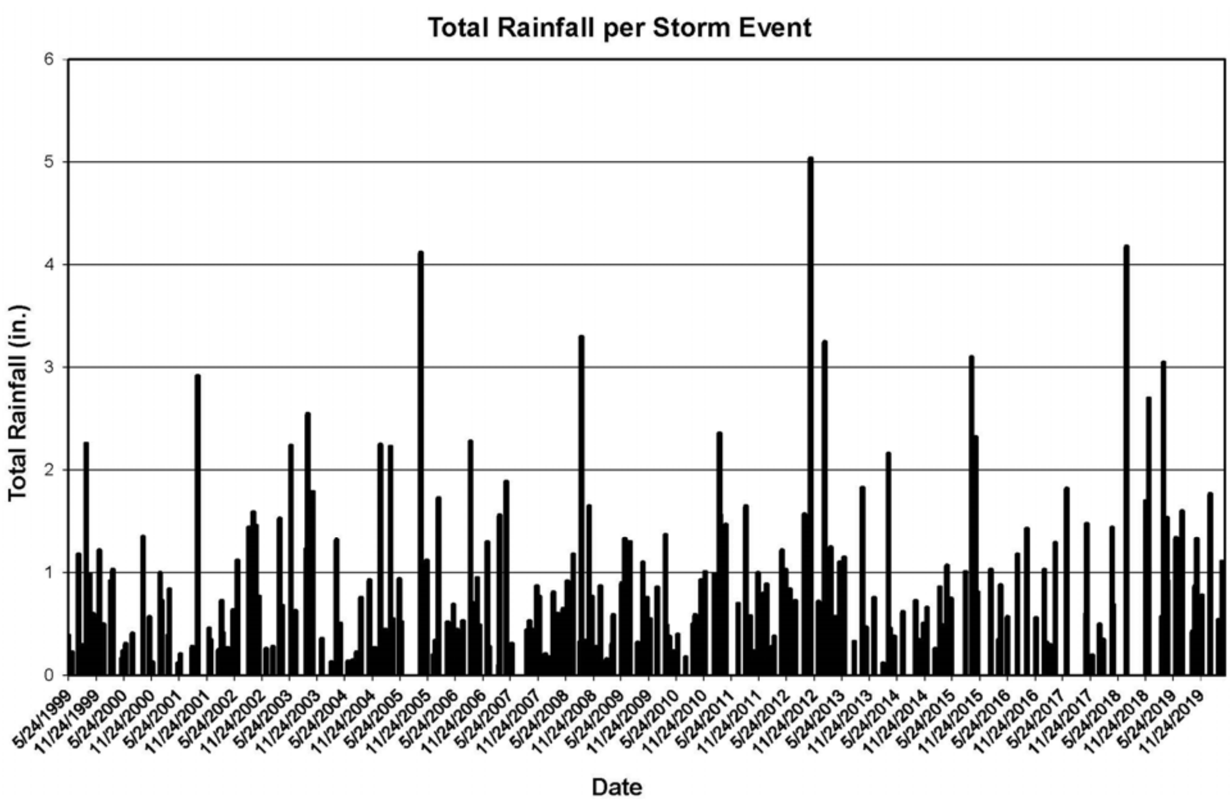

Figure 2-3. Rainfall totals for sampled storm events (May 1999 to July 2020)

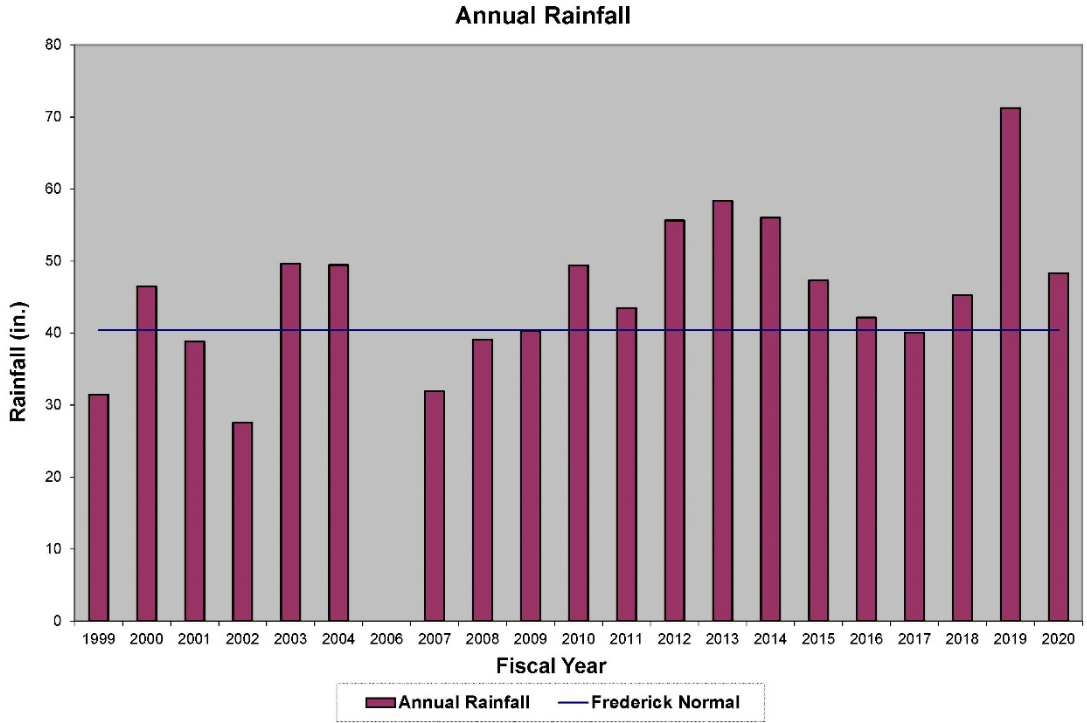

Figure 2-4. Annual rainfall recorded at NOAA's Emmitsburg, MD station, FY1999-2008 (no data for FY2006) and at NOAA's Clarksburg, MD station, FY2009-2020. Note: Emmitsburg data for FY2007 do not include July 2006 and June 2007.

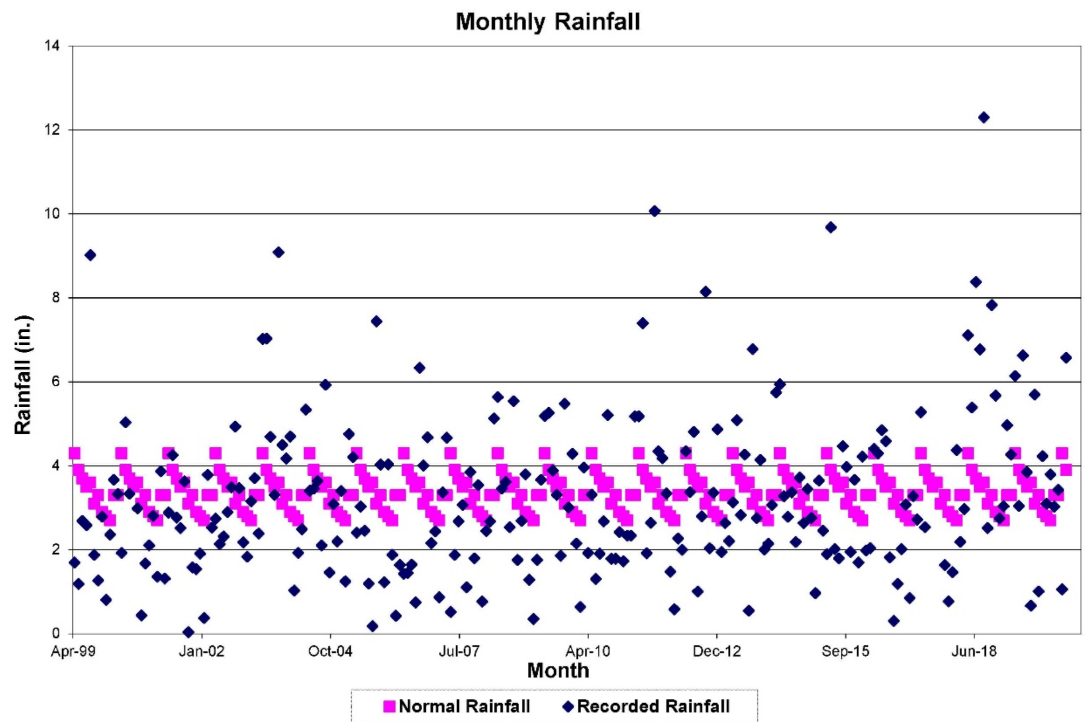

Figure 2-5. Monthly rainfall recorded at the Peter Pan site (at instream station prior to early 2003; at Pond-R after early 2003) and NOAA's long-term Frederick County regional average monthly (i.e., normal) rainfall, April 1999 – July 2020.

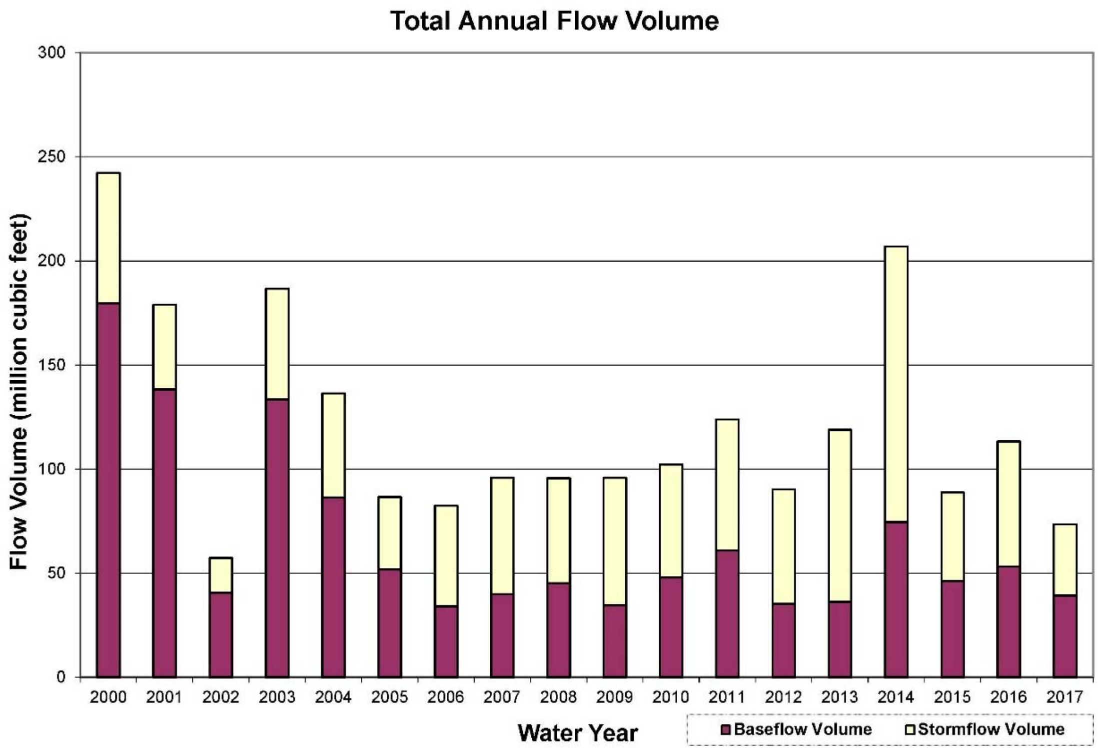

Figure 2-6a. Annual discharge volume measured at the Peter Pan Run instream monitoring station, WY2000 – WY2017.

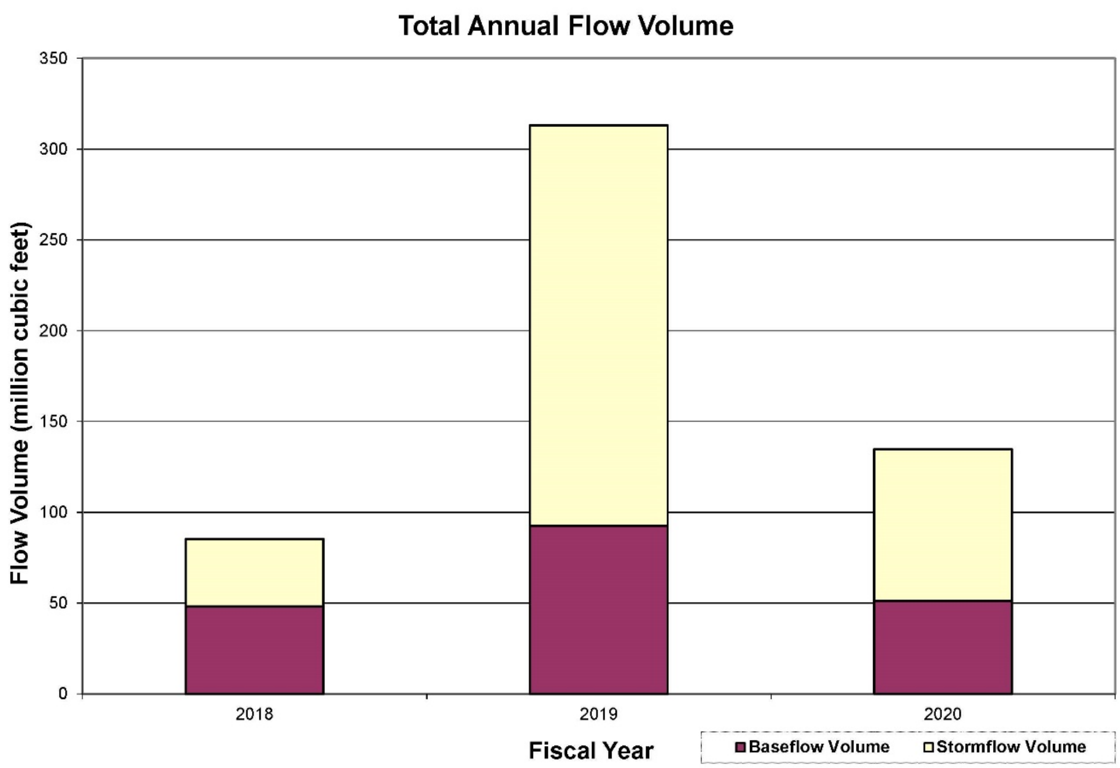

Figure 2-6b. Annual discharge volume measured at the Peter Pan Run instream monitoring station, FY2018 – FY2020.

2.1.3 Water Chemistry Analysis

Laboratory and Field Results

A summary of analytical results for baseflow and storm event water chemistry monitoring at the Peter Pan Run instream station and Pond-R outfall station from July 2019 through June 2020 are shown in Tables 2-4a through 2-4c. Baseflow monitoring analytical results from the Peter Pan Run instream station includes twelve samples during the period of July 2019 to June 2020.

Table 2-4a. FY2020 water chemistry results for instream storm event monitoring at Peter Pan Run (PPAN01)

Date	Sampling Period	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
9/30/2019	Rising	< 2	0.7	2.50	0.11	180	29	6.0	< 2	19.6	< 2.7	1,990
	Peak	< 2	0.3	2.30	0.08	190	27	2.2	< 2	20.1	3	4,710
	Falling	< 2	0.4	2.30	0.09	190	6	2.8	< 2	20.5	< 2.7	4,710
10/16/2019	Rising	< 2	< 0.2	2.70	0.06	170	20	3.0	< 2	18.2	< 2.7	2,420
	Peak	< 2	0.4	1.40	0.26	140	160	4.1	3.0	27.9	< 2.7	8,390
	Falling	< 2	0.2	1.20	0.06	140	18	2.2	< 2	63.2	< 2.7	3,680
10/27/2019	Rising	3	0.3	2.30	0.04	180	6	< 2	< 2	20.2	6.2	1,200
	Peak	< 2	1.1	0.93	0.27	100	230	8.0	5.2	76.8	3.4	3,890
	Falling	< 2	0.2	0.88	0.03	100	14	< 2	< 2	19.7	< 2.7	1,730
11/24/2019	Rising	3	< 0.2	2.40	0.05	170	10	5.6	< 2	20.3	< 2.7	387
	Peak	2	0.3	1.90	0.05	150	21	5.2	< 2	20.7	< 2.7	1,990
	Falling	< 2	0.3	1.50	0.02	130	5	2.3	< 2	17.1	< 2.7	378
12/1/2019	Rising	2	< 0.2	2.50	0.05	180	6	< 2	< 2	17.1	3.1	365
	Peak	< 2	0.2	1.50	0.06	140	13	< 2	< 2	20.0	< 2.7	1,550
	Falling	2	0.2	1.40	0.03	120	4	< 2	< 2	20.7	4.6	326
1/25/2020	Rising	< 2	0.7	2.50	0.31	160	310	7.6	6.1	33.9	< 2.7	517
	Peak	< 2	1.3	1.10	0.38	72	440	14.8	9.9	54.3	< 2.7	2,420
	Falling	< 2	0.3	1.30	0.08	80	35	4.2	< 2	17.0	< 2.7	461
3/19/2020	Rising	3	0.3	2.40	0.03	140	9	2.2	< 2	12.3	< 2.7	166
	Peak	< 2	0.2	1.70	0.05	140	18	2.3	< 2	13.0	< 2.7	501
	Falling	< 2	< 0.2	1.60	0.02	160	2	< 2	< 2	7.5	< 2.7	186
4/13/2020	Rising	3	0.7	1.90	0.29	130	100	4.8	2.8	17.8	< 2.7	1,710
	Peak	< 2	0.4	1.20	0.17	92	76	4.9	< 2	13.1	< 2.7	2,420
	Falling	< 2	0.2	1.40	0.04	100	13	2.6	< 2	9.8	< 2.7	1,300
4/30/2020	Rising	< 2	0.4	2.50	0.25	120	130	3.9	2.4	17.3	6.1	1,990
	Peak	< 2	1.1	1.60	0.29	69	220	7.2	4.0	22.8	< 2.7	2,980
	Falling	< 2	0.3	1.50	0.06	77	25	3.3	< 2	13.4	< 2.7	1,550

Results are in mg/L except *E. coli* results are in MPN/ 100 mL. Metals results are in µg/L.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Shaded values indicate results that exceeded Maryland surface water quality acute criteria as depicted in Table 2-5.

Table 2-4b. FY2020 water chemistry results for baseflow monitoring at instream Peter Pan Run (PPAN01)

Date	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
7/29/2019	< 2	0.2	3.10	0.02	150	1	< 2	< 2	13	6.2	238
8/7/2019	< 2	1.6	2.90	0.02	170	5	< 2	< 2	11.8	3.4	142
9/6/2019	< 2	< 0.2	2.50	0.01	160	2	< 2	< 2	19.8	3.1	435
10/15/2019	< 2	< 0.2	2.50	0.01	190	2	23.7	< 2	17.2	< 2.7	147
11/21/2019	< 2	< 0.2	2.90	< 0.01	170	1	< 2	< 2	13.9	3.3	48
12/13/2019	< 1	0.4	2.20	< 0.01	160	< 1	< 2	< 2	15.3	< 2.7	24
1/15/2020	< 2	< 0.2	3.00	< 0.01	160	< 1	< 2	< 2	12.2	< 2.7	34
2/24/2020	< 2	< 0.2	2.90	< 0.01	170	< 1	< 2	< 2	10.4	2.9	19
3/18/2020	< 2	0.2	2.40	0.05	180	< 1	< 2	< 2	14.1	< 2.7	52
4/21/2020	< 2	0.2	2.70	< 0.01	150	2	< 2	< 2	8.7	< 2.7	62
5/15/2020	< 2	< 0.2	2.90	< 0.01	150	1	< 2	< 2	7.7	< 2.7	91
6/30/2020	< 2	0.2	2.50	0.03	140	6	< 2	< 2	8.7	< 2.7	308

Results are in mg/L except *E. coli* results are in MPN/100 ml. Metals results are in µg/l.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Table 2-4c. FY2020 water chemistry results for outfall storm event monitoring at Pond-R

Date	Sampling Period	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
9/30/2019	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/16/2019	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/27/2019	Rising	2	0.3	0.08	0.19	51	6	9.3	< 2	32.5	8.5	16
	Peak	< 2	0.3	< 0.05	0.02	45	1	2.9	< 2	25.5	5.3	84
	Falling	< 2	0.3	< 0.05	0.03	45	2	3.4	< 2	23.7	< 2.7	816
11/24/2019	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/1/2019	Rising	4	0.2	0.05	0.13	84	3	5.5	< 2	26.0	< 2.7	345
	Peak	4	0.2	< 0.05	0.16	74	3	5.9	< 2	24.0	< 2.7	81
	Falling	10	0.6	0.06	0.20	60	4	7.3	< 2	32.1	< 2.7	93
1/25/2020	Rising	< 2	0.2	0.08	0.25	88	8	2.0	< 2	15.2	< 2.7	65
	Peak	< 2	< 0.2	0.09	0.10	48	13	2.3	< 2	14.2	< 2.7	107
	Falling	< 2	0.2	0.12	0.10	44	12	3.2	< 2	13.4	< 2.7	225
3/19/2020	Rising	3	0.3	0.07	0.12	60	6	2.4	< 2	19.1	< 2.7	9
	Peak	< 2	0.2	0.06	0.07	92	3	2.2	< 2	12.8	< 2.7	10
	Falling	< 2	0.2	0.08	0.05	92	2	< 2	< 2	13.4	< 2.7	13
4/13/2020	Rising	< 2	0.3	0.05	0.12	58	6	2.8	< 2	17.9	< 2.7	10
	Peak	< 2	0.6	< 0.05	0.05	58	3	2.0	< 2	13.9	< 2.7	461
	Falling	< 2	0.2	0.08	0.06	50	4	3.0	< 2	13.6	< 2.7	1,300
4/30/2020	Rising	< 2	0.3	< 0.05	0.06	50	4	3.6	< 2	16.6	< 2.7	8
	Peak	< 2	0.6	< 0.05	0.07	53	5	3.8	< 2	14.4	< 2.7	980
	Falling	4	0.3	< 0.05	0.1	50	12	4.3	< 2	16.6	5.3	1,550

Results are in mg/L except *E. coli* results are in MPN/100 mL. Metals results are in µg/L.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Calculation of Event Mean Concentration

Storm event mean concentrations (EMC) of the various pollutants at each station were calculated from laboratory results and flow rate data from the monitored storms. To arrive at the EMC of a particular pollutant, a volume-weighted average was calculated for the rising, peak, and falling limbs of each storm hydrograph. Stage data were collected at five-minute intervals at the Peter Pan instream and the Pond-R outfall monitoring stations. Rating curves were developed using in-situ flow and stage measurements at the Peter Pan instream station and Manning's equation applied to the Pond-R outfall pipe. Flow rate data were estimated by applying the rating curves to the measured stage data at both stations.

Table 2-5 presents the calculated annual average EMCs compared to Maryland freshwater acute and chronic water quality criteria, average EMC values reported by the MDE for NPDES Part 2 sampling from jurisdictions across the State (Bahr 1997), and values reported in two national datasets. The National Urban Runoff Program (NURP) average EMC values were taken from median urban site concentration results. The National Stormwater Quality Database (Maestre and Pitt 2005) average values are from a more recent national compilation of data from stormwater runoff in a variety of conveyances in residential land use.

Comparisons with Maryland water quality criteria are presented only as a general aid to interpreting the data and are not intended as a regulatory review to assess compliance with standards. Maryland Drinking Water Criteria are listed because Peter Pan Run is designated as a "Use Class I-P" stream (potential public water supply), as are many waterways in Frederick County, and as such are subject to State drinking water criteria. Flow-weighted EMC data for each pollutant for each storm event have been submitted electronically as part of the County's Annual Report geodatabase submission.[1] Note that for the purpose of discussion, EMCs and baseflow mean concentrations (MCs) were calculated with non-detectible results set to zero.

[1]In the electronic database containing storm EMCs and baseflow mean concentrations, the following apply: (1) storm duration signifies the time period between the beginning of the rising limb and the ending of the falling limb of a particular storm; (2) data fields with entries "ND" denote samples not collected, tests not performed or field not applicable; (3) flow-weighted mean temperatures and pH were determined by averaging the individual temperature and pH measurements as taken by an *in-situ* recording device (e.g., AQ700 multi-parameter sonde) over the course of the monitoring of the storm event from the beginning of the rising limb to the end of the falling limb and obtaining the flow-weighted means of those overall averages.

Table 2-5. Comparison of annual average Peter Pan Run event mean concentrations (EMCs) from storms sampled between July 1, 2019 and June 30, 2020, with Maryland state average EMCs for all land uses, with values from two national datasets, and with Maryland water quality standards

Parameter	Average Annual Peter Pan Run EMC[a] (mg/l)	Average Annual Pond-R Outfall EMC[a] (mg/l)	Average MD EMC[b] (mg/l)	NSQD Residential Median[c] (mg/l)	NURP Runoff Water Quality EMC[d] (mg/l)	Part 2 Outfall EMC (mg/l)[e]	MD Freshwater Acute Criteria (mg/l)	MD Freshwater Chronic Criteria (mg/l)	MD Drinking Water Criteria (mg/l)
BOD	0.69 – 2.38	0.25 – 2.29	14.44	9	9	4.34	N/A	N/A	N/A
TKN	0.67 – 0.68	0.36 – 0.42	1.94	1.5	1.5	1.03	N/A	N/A	N/A
Nitrate + Nitrite	1.39	0.06 – 0.09	0.85	0.6	0.68	N/A	N/A	N/A	N/A
Total Phosphorus	0.20	0.09	0.33	0.31	0.33	0.13	N/A	N/A	N/A
Hardness	90	50	N/A	32	N/A	N/A	N/A	N/A	N/A
TSS	188	9	66.57	49	100	15.21	N/A	N/A	N/A
Copper	0.0068 – 0.0069	0.0029	0.0179	0.012	0.034	0.0095	0.013	0.009	1.3
Lead	0.0033 – 0.0045	0.0000 – 0.0020	0.0125	0.012	0.144	0.0046	0.065	0.0025	0.015
Zinc	0.0276	0.0151	0.1433	0.073	0.16	0.0644	0.12	0.12	N/A

(a) Where concentrations reported at the detection limit, loadings are presented as range of possible values, setting concentrations below the detection limit to zero or to the actual detection limit value.
(b) Maryland State average values from Bahr 1997.
(c) National Stormwater Quality Database values from Maestre and Pitt 2005.
(d) National Urban Runoff Program values from U.S. EPA 1983.
(e) Frederick County Part 2 Outfall Sampling Results from Third Annual Report 1999.
N/A = No value or criteria established
EMC = volume-weighted event mean concentration

Instream Event Mean Concentrations

During FY2020, average annual storm EMCs for all pollutants, except for hardness, decreased from FY2019 levels. During baseflow conditions, nitrate and nitrite and TPH decreased from FY2019 levels and TSS and Lead stayed the same where all other pollutants increased. BOD was not detected in baseflow samples for a ninth consecutive year. Average hardness concentrations have remained consistent since FY2012 with a 9% increase in baseflow mean concentrations and a 17% increase in EMCs since FY2019. Average hardness concentrations are lower during storm events in comparison to baseflow. TPH was detected during five storm events and in five baseflow samples taken at the instream station during FY2020. This is similar to TPH detections in FY2019, but more than in FY2018.

Average baseflow concentrations of combined nitrate and nitrite steadily increased between FY2009 and FY2015, reduced in FY2017, and began to increase in FY2018 and FY2019 with a decrease by 16% in FY2020. The average annual storm EMC for combined nitrate and nitrite has remained at a fairly consistent level since FY2009 with a 14% decrease for FY2020 since FY2019. Average baseflow concentrations of nitrate and nitrite are consistently higher than average storm flow concentrations for the entire monitoring period. This is likely caused by active and legacy agricultural land use within the watershed and nitrate and nitrite leaching into groundwater during baseflow conditions. TKN average baseflow concentrations have remained consistently low since FY2012 and have increased by 48% since FY2019. Average storm EMCs of TKN have been measured on an increasing trend since FY1999 until the beginning of a decreasing trend in FY2017. Storm runoff TKN levels have been low and consistent since FY2018 with a slight increase by 16% in FY2020 compared to FY2019 (Figure 2-7).

Excluding a spike in concentration level in FY2009, average baseflow phosphorus concentrations have shown an overall declining trend since FY2004 with consistently low concentrations measured since FY2013. The baseflow mean phosphorus concentration increased slightly by 5% since FY2020. The average storm event concentration of phosphorus in FY2020 was 35% lower than the average in FY2019. Phosphorus storm event mean concentrations peaked between FY2008 and FY2011 but have not shown any other trend. The average phosphorus storm event concentration decreased significantly in FY2012 and has remained fairly consistent ever since (Figure 2-8).

FY2020 storm runoff TSS concentrations decreased by 60% and baseflow TSS concentrations stayed the same in comparison to FY2019. TSS average baseflow concentrations have been negligible compared to average storm event concentrations for the entire monitoring period. TSS EMCs have largely fluctuated over the monitoring period and had been on a decreasing trend until FY2010 where the averages began an increasing trend that peaked in FY2016 (Figure 2-8). The annual EMCs began to decrease since FY2016, increased for FY2019 and decreased again in FY2020.

E. coli was detected in all baseflow and storm event samples at the Peter Pan Run instream station in FY2020. Average *E. coli* baseflow and stormflow concentrations increased by 22% and 37% respectively since FY2019. *E. coli* concentrations were typically higher during peak storm samples. The lowest concentrations of *E. coli* are generally found during the colder months.

Sample analytical results for *E. coli* are within the same range and slightly lower on average than in FY2018 and FY2019. Typical sources of *E. coli* in surface waters in a watershed include wildlife, pet waste, and malfunctioning septic or sewage treatment systems (Vann et al. 2002).

Annual storm EMCs for copper, lead, and zinc decreased from FY2019 values by 31%, 64%, and 46% respectively. Copper and lead storm EMCs have measured at consistent levels since FY2000 while zinc has fluctuated since FY2005 after a decreasing trend. The EMCs for all three metals have followed a decreasing trend since FY2016 until increasing in FY2019 and decreasing again in FY2020. Corresponding annual mean concentrations of metals in baseflow have remained consistently low or not detected since FY1999 (Figure 2-9). One copper sample concentration in FY2020 exceeded the freshwater acute criterion of 0.013 mg/L (1/25/2020; Figure 2-10).

Calculated EMCs for metals may be compared to the standards listed in Table 2-5. However, it is important to note that Maryland State water quality criteria for metals are presented in terms of dissolved metals only and results are reported as total metals. Only the dissolved portion of metals is readily available for biological uptake. Because metals tend to sorb to suspended solids and organic matter, the portion of the particulate form of the metal is often larger than the portion of the dissolved form. NPDES stormwater samples are analyzed for total metal concentrations (as required by the NPDES permit and MDE's recommended protocols) making it more difficult to draw a direct comparison. Therefore, our analysis is not meant to specifically determine whether these constituents meet State water quality standards. Rather we present this information to provide a general indication of overall stream quality. All average annual storm EMCs and average annual MCs for metals did not exceed their respective acute and chronic criteria. No storm runoff sample metals concentration results exceeded their respective Maryland freshwater criteria at the instream station.

Home construction, natural sources, and automobile use are likely primary contributors to high metal concentrations in watershed runoff. Atmospheric deposition is a source of copper and zinc. Zinc and cadmium are deposited on surfaces as a result of tire wear. Wear on brake pad linings contributes to copper in runoff. Vehicle emissions are a primary source of lead in storm runoff (San Diego Regional Water Quality Control Board 2000). Used motor oil contains zinc, cadmium, lead, and other heavy metals (USDHHS 1997).

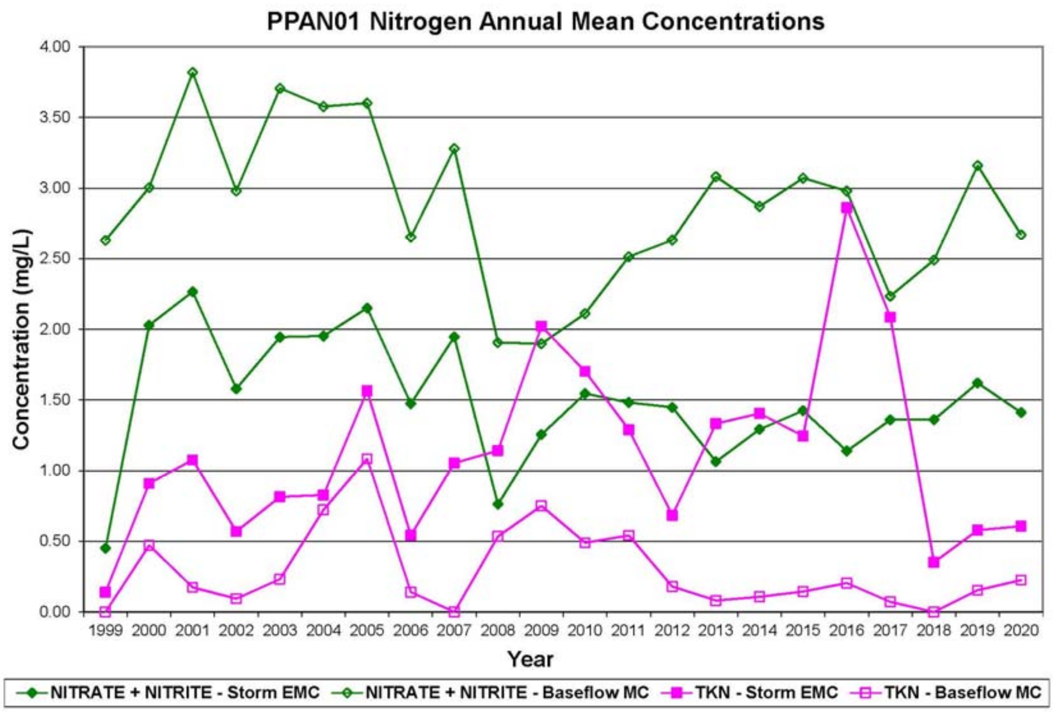

Figure 2-7. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Peter Pan Run instream site (FY1999 – FY2020)

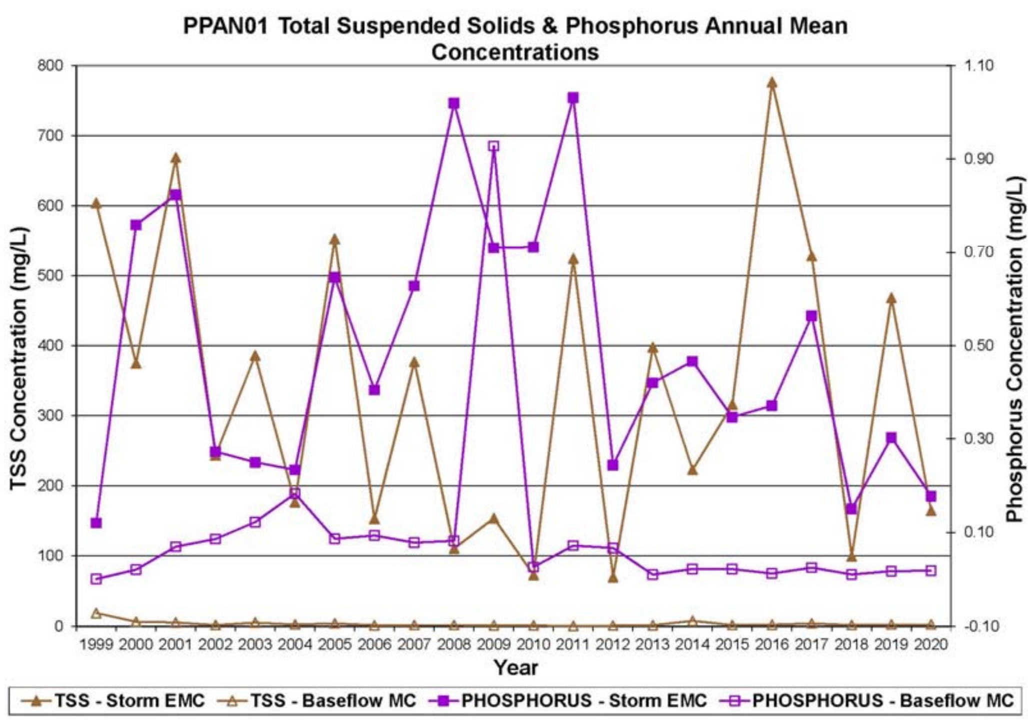

Figure 2-8. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at the Peter Pan Run instream station (FY1999 – FY2020)

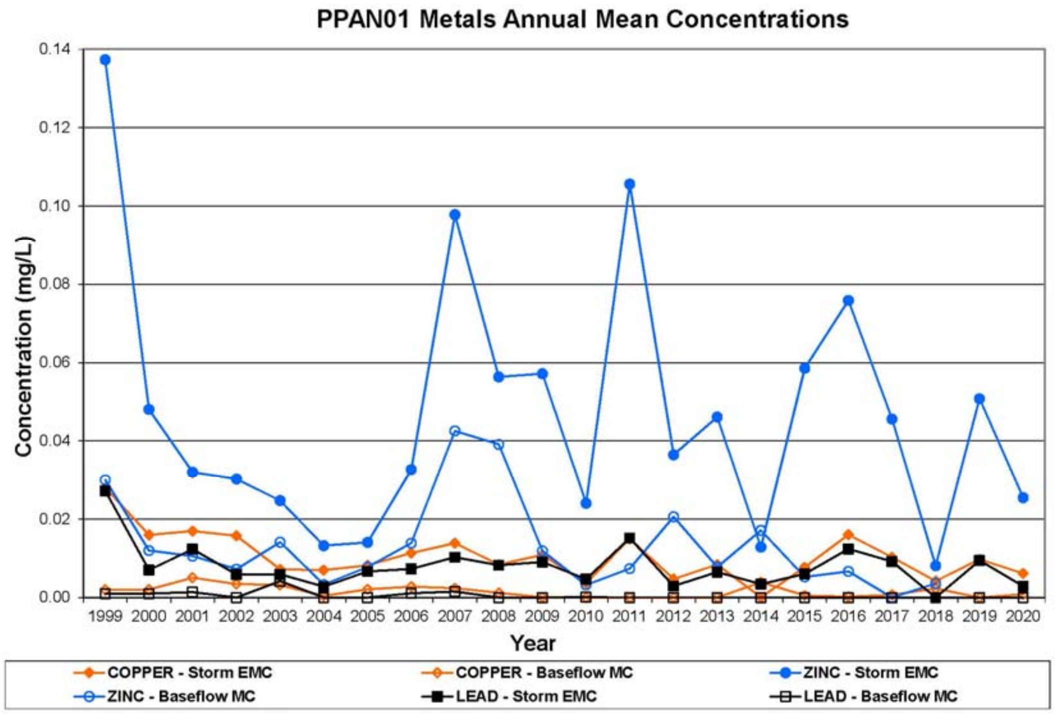

Figure 2-9. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper, zinc, and lead at the Peter Pan Run instream station (FY1999 – FY2020)

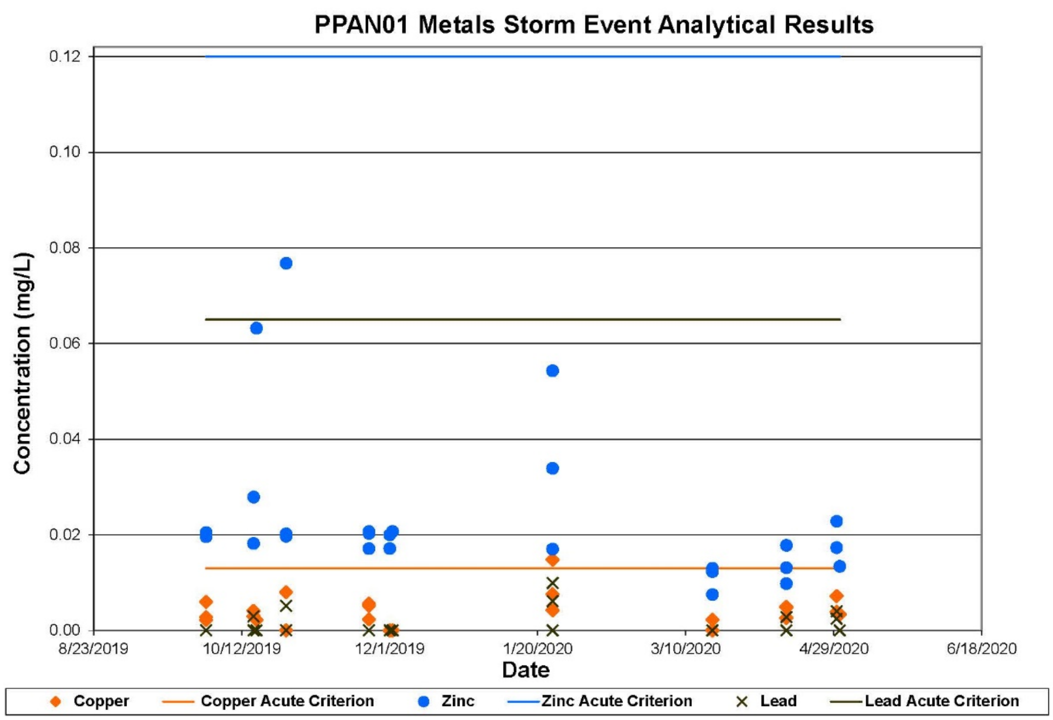

Figure 2-10. Copper, Zinc, and lead analytical results in storm runoff at the instream station (FY2020) compared to acute criteria

Outfall Event Mean Concentrations

Monitored results at this station prior to FY2019 represent a dry extended detention stormwater BMP. Whereas results in FY2019 and FY2020 represent a wet extended detention stormwater BMP design and may not correlate to historical data. Average annual storm EMCs at the outfall in FY2020 decreased or stayed about the same for all parameters except hardness compared to FY2019. The average annual storm EMC for BOD and hardness decreased by 83% and increased by 63% respectively in FY2020 compared to FY2019. TPH was detected during two FY2020 storms (10/27/2020, 4/30/2020). TPH has been minimal or not been detected in storm samples since 2010. *E. coli* was detected in all FY2020 storm samples and the average annual storm EMC for *E. coli* was 45% lower than in FY2019. TKN, phosphorus, and TSS, annual EMCs have been generally lower at the Pond-R outfall in comparison to EMCs measured at the instream station for the entire monitoring period.

Average concentrations of combined nitrate and nitrite carried by stormflow at the Pond-R outfall decreased by 66% in FY2020 compared to FY2019, continuing a decreasing trend since FY2018. The annual storm EMC for TKN decreased by 55%, returning to low concentrations since FY2019 (Figure 2-11).

The average annual storm EMC for phosphorus at the Pond-R site decreased by 35% in FY2020, following a level trend after a significant spike in EMC in FY2008. The average annual storm EMC for TSS decreased by 55% in FY2020, returning to low concentrations since FY2019. The pond retrofit completed in November 2019 may have contributed to the increase of TSS at the outfall during FY2019. TSS EMCs were measured at high levels at the beginning of the monitoring period in FY2003. After the conversion of Pond-R from a sediment basin to an extended dry detention pond in July 2004, TSS EMCs dropped significantly but have been variable ever since (Figure 2-12).

The average annual storm EMC's for copper, lead, and zinc were 37%, 100%, and 9% lower, respectively, in FY2020 than in FY2019 (Figure 2-13). Storm EMCs of copper have remained consistent since FY2009. After a spike in FY2008, zinc EMCs dropped to a consistent concentration until FY2016 when the EMC dropped even further. No metals concentration results exceeded the freshwater acute criterion at the pond outfall in FY2020 (Figure 2-14). Lead was not detected in any storm samples at Pond-R in FY2020. Lead has been minimally or not been detected in the pond outfall storm samples since 2016.

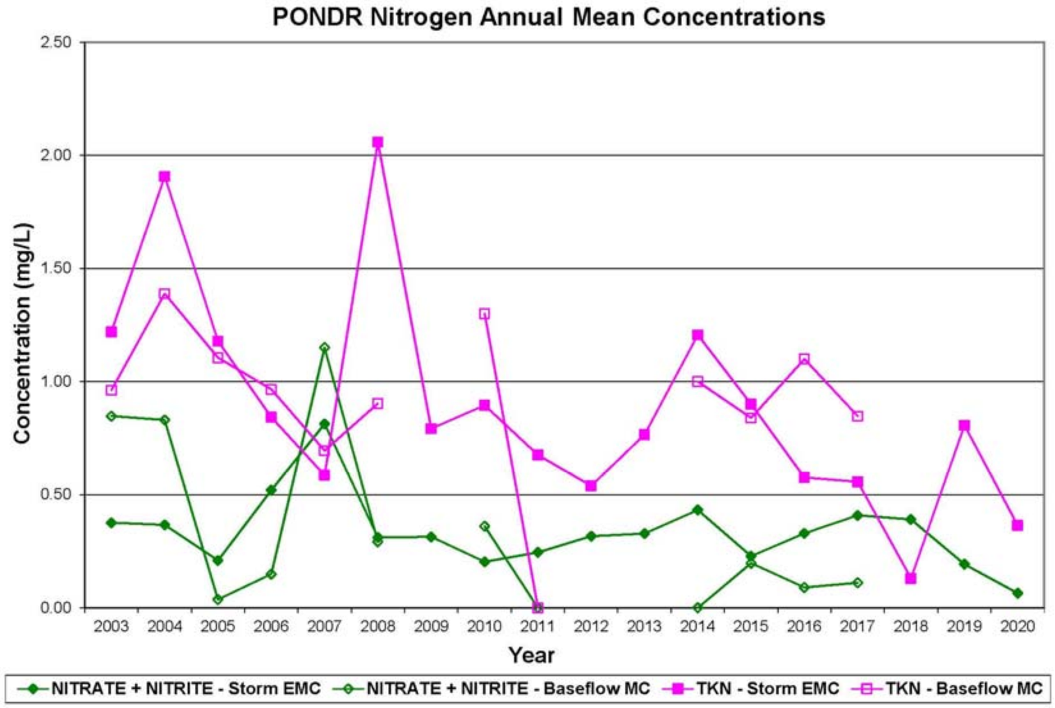

Figure 2-11. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Pond-R outfall site (FY2003 – FY2020)

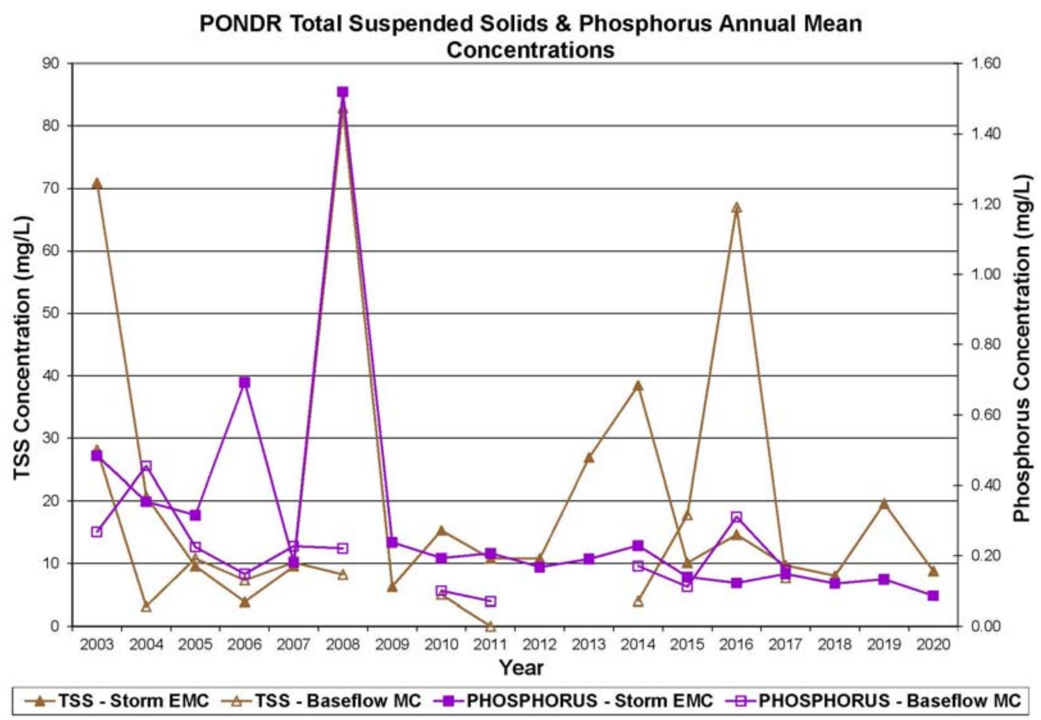

Figure 2-12. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at the Pond-R outfall station (FY2003 – FY2020)

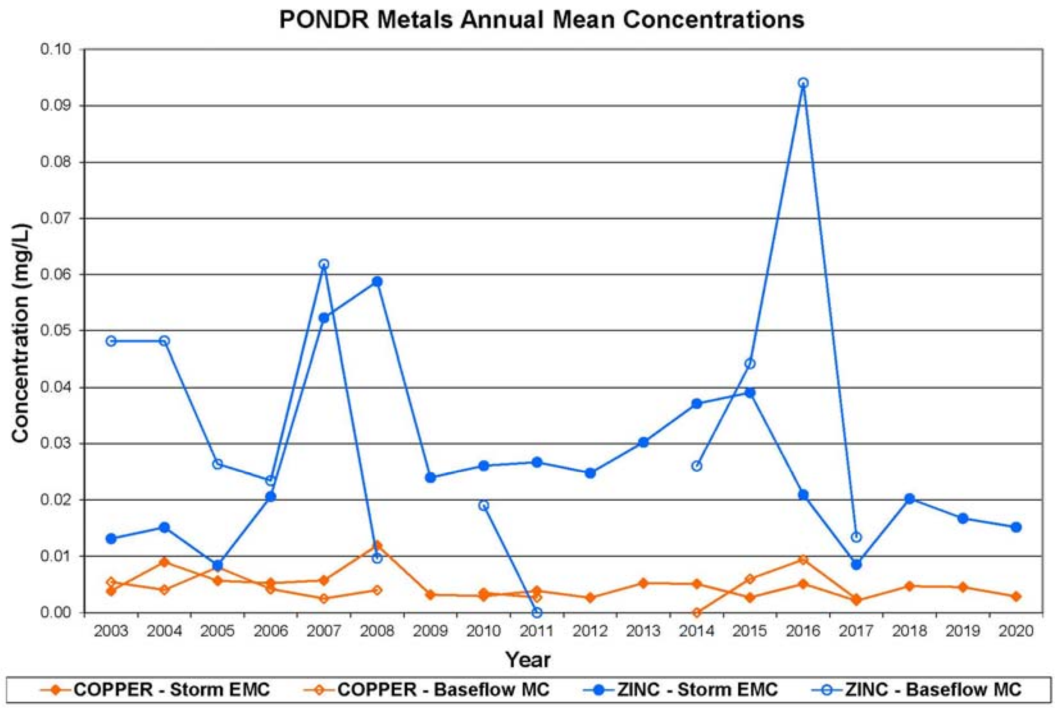

Figure 2-13. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper and zinc at Pond-R outfall station (FY2003 – FY2020) Note: Lead EMCs have been measured less than 0.0093 mg/L and are not shown.

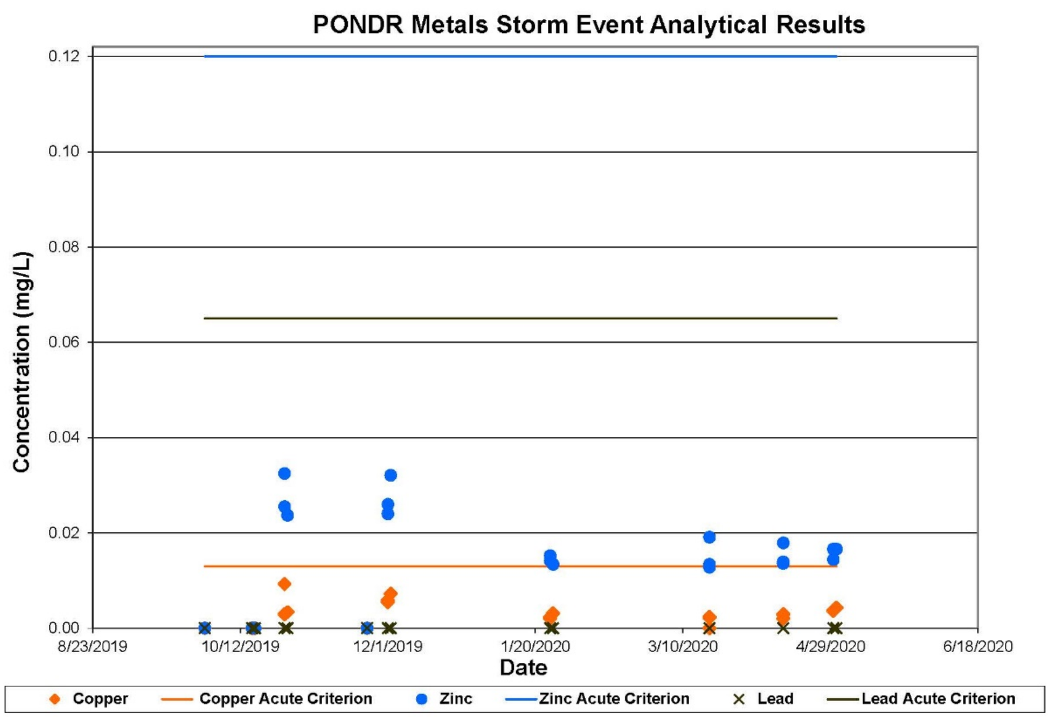

Figure 2-14. Copper, zinc, and lead analytical results in storm runoff at the Pond-R outfall station (FY2020) compared to acute criteria

2.1.4 Pollutant Loading Estimates for Peter Pan Run and Pond-R Outfall

Pollutant loading estimates, as required by the conditions of this MS4 permit, were calculated for each storm event for both the instream and outfall stations (Tables 2-6a and 2-6b). Total storm event loadings were calculated by multiplying the storm EMC for each parameter, the corresponding total volume for that storm event calculated from stage data collected by the ISCO meter, and the appropriate conversion factor to obtain pounds. Methods for determining calculation factors are outlined in Appendix B.

Annual and seasonal loading estimates were calculated using estimated flow and analyzed concentration data from both the Peter Pan Run instream station and the Pond-R outfall station over a twelve-month period (July 1, 2019 through June 30, 2020). The July 22, 2019 storm, which counted as a storm in FY2019, was used in the summer season calculations. Tables 2-6a and 2-6b show comparative estimated results of stormflow pollutant loadings at the Peter Pan Run instream and Pond-R stations for the storms sampled. An analogous calculation was used to determine seasonal and annual loading estimates. Seasonal and annual loading estimates for the instream and pond outfall stations are presented in Tables 2-7a and 2-7b. Note that loading estimates are based on calculations from continuous flow rate data as well as a sampled subset of storms that represent less than the actual amount of storms that occurred in the watershed. Storm characteristics (i.e., size, duration, intensity, time of year, antecedent dry time) of the storms actually monitored may affect loading calculations in a given year.

Table 2-6a. Storm event flow volume per storm event at the instream station of Peter Pan Run*												
Date	**Total Storm Volume (cf)**	**Total Storm Volume (acre-ft)**	**BOD**	**TKN**	**Nitrate + Nitrite**	**Total Phosphorus**	**TSS**	**Copper**	**Lead**	**Zinc**	**TPH**	***E. coli***
9/30/2019	143,169	3.29	0.00 – 17.88	3.50	20.71	0.79	136.63	0.03	0.00 – 0.02	0.18	9.31 – 25.06	1.81×10^{11}
10/16/2019	489,205	11.23	0.00 – 61.08	9.28 – 9.56	42.23	5.29	3,006.97	0.10	0.05 – 0.08	1.26	0.00 – 82.46	8.71×10^{11}
10/27/2019	1,212,819	27.84	13.21 – 155.83	54.54	75.05	12.7	10,375.56	0.35 – 0.41	0.22 – 0.29	3.97	174.50 – 250.15	1.01×10^{12}
11/24/2019	129,755	2.98	7.35 – 16.59	2.31 – 2.39	13.74	0.27	91.80	0.03	0.00 – 0.02	0.15	0.00 – 21.87	3.64×10^{10}
12/1/2019	339,677	7.80	21.49 – 42.41	4.00 – 4.24	32.07	0.97	181.39	0.00 – 0.04	0.00 – 0.04	0.53	47.61 – 75.85	8.96×10^{10}
1/25/2020	4,006,190	91.97	0.00 – 500.20	180.96	307.57	52.10	51,975.02	2.17	1.06 – 1.34	8.21	0.00 – 675.26	1.45×10^{12}
3/19/2020	767,922	17.63	13.52 – 100.39	4.28 – 10.04	81.77	1.44	361.83	0.04 – 0.10	0.00 – 0.10	0.46	0.00 – 129.44	6.10×10^{10}
4/13/2020	1,781,783	40.90	28.33 – 231.91	37.74	149.68	13.81	5,660.65	0.44	0.03 – 0.23	1.34	0.00 – 300.33	9.47×10^{11}
4/30/2020	3,589,815	82.41	0.00 – 448.21	139.99	355.92	36.11	24,209.43	1.10	0.39 – 0.63	3.89	65.91 – 641.82	2.18×10^{12}

Flow volume in cubic feet and acre-feet and pollutant loads in pounds (*E. coli* in MPN)
NC = sample not collected.
*Where concentrations reported below detection limit, loads are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 2-6b. Storm event flow volume and event mean concentrations per storm event at the Pond-R Outfall*												
Date	**Total Storm Volume (cf)**	**Total Storm Volume (acre-ft)**	**BOD**	**TKN**	**Nitrate + Nitrite**	**Total Phosphorus**	**TSS**	**Copper**	**Lead**	**Zinc**	**TPH**	***E. coli***
10/27/2019	24,353	0.56	0.19 – 3.04	0.46	0.01 –0.08	0.05	2.27	0.01	0.00	0.04	6.85 – 7.62	1.49×10^{9}
12/1/2019	7,023	0.16	3.57	0.21	0.02	0.08	1.62	0.00	0.00	0.01	0.00 – 1.18	2.15×10^{8}
1/25/2020	96,778	2.22	0.00 – 12.08	1.21	0.59	0.63	76.14	0.02	0.00 – 0.01	0.08	0.00 – 16.31	3.76×10^{9}
3/19/2020	5,844	0.13	0.09 – 0.76	0.08	0.03	0.02	0.97	0.00	0.00	0.00	0.00 – 0.99	1.93×10^{7}
4/13/2020	25,358	0.58	0.00 – 3.17	0.76	0.09	0.09	5.38	0.00	0.00	0.02	0.00 – 4.27	4.81×10^{9}
4/30/2020	77,904	1.79	2.74 – 11.10	2.66	0.00 – 0.24	0.36	28.92	0.02	0.00 – 0.01	0.07	0.00 – 14.91	2.26×10^{10}

Flow volume in cubic feet and acre-feet and pollutant loads in pounds (*E. coli* in MPN)
*Where concentrations reported below detection limit, loads are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 2-7a. Seasonal and FY2020 baseflow and stormflow concentrations and loads at the instream Peter Pan Run station.*											
		BOD	**TKN**	**Nitrate + Nitrite**	**Total Phosphorus**	**TSS**	**Copper**	**Lead**	**Zinc**	**TPH**	***E. coli***
Summer (Jul. – Sep. 2019)	Average Storm EMC (mg/L)	4.24 - 4.41	1.23	1.28	0.40	533	0.0123	0.0093 - 0.0095	0.0548	2.34 - 3.69	8,829
	Estimated Total Storm Load (lbs)	4,693 - 4,879	1,366	1,421	440	589,991	13.57	10.34 - 10.53	60.62	2,589 - 4,082	4.43×10^{13}
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.63 - 0.68	2.88	0.02	2.62	0.0000 - 0.0020	0.0000 - 0.0020	0.0143	4.48	253
	Estimated Total Baseflow Load (lbs)	0 - 1,827	577 - 622	2,635	16	2,393	0.00 - 1.83	0.00 - 1.83	13.02	4,091	1.05×10^{12}
	Total Estimated Seasonal Load (lbs)	4,693 - 6,706	1,943 - 1,988	4,056	456	592,384	13.57 - 15.40	10.34 - 12.36	73.65	6,680 - 8,174	4.53×10^{13}
Fall (Oct. – Dec. 2019)	Average Storm EMC (mg/L)	0.31 - 2.04	0.52 - 0.52	1.20	0.14	101	0.0035 - 0.0043	0.0020 - 0.0031	0.0428	1.64 - 3.17	3,260
	Estimated Total Storm Load (lbs)	240 - 1,573	400 - 403	930	110	77,834	2.71 - 3.32	1.57 - 2.42	33.06	1,266 - 2,453	1.14×10^{13}
	Average Baseflow MC (mg/L)	0.00 - 1.61	0.16 - 0.28	2.49	0.00 - 0.01	0.97 - 1.36	0.0085 - 0.0098	0.0000 - 0.0020	0.0156	0.84 - 2.85	74
	Estimated Total Baseflow Load (lbs)	0 - 585	56 - 101	902	1 - 4	352 - 493	3.08 - 3.55	0.00 - 0.73	5.67	304 - 1,035	1.22×10^{11}
	Total Estimated Seasonal Load (lbs)	240 - 2,158	456 - 504	1,831	111 - 113	78,187 - 78,327	5.79 - 6.87	1.57 - 3.15	38.73	1,570 - 3,488	1.15×10^{13}
Winter (Jan. – Mar. 2020)	Average Storm EMC (mg/L)	0.05 - 2.02	0.62 - 0.64	1.31	0.18	176	0.0074 - 0.0076	0.0035 - 0.0048	0.0291	0.00 - 2.70	1,121
	Estimated Total Storm Load (lbs)	64 - 2,823	871 - 898	1,830	252	245,965	10.41 - 10.68	4.97 - 6.76	40.75	0 - 3,782	7.12×10^{12}
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.09 - 0.20	2.70	0.02 - 0.03	0.00 - 1.00	0.0000 - 0.0020	0.0000 - 0.0020	0.0123	1.21 - 2.78	36
	Estimated Total Baseflow Load (lbs)	0 - 1,940	84 - 194	2,617	21 - 27	0 - 970	0.00 - 1.94	0.00 - 1.94	11.91	1,176 - 2,701	1.56×10^{11}
	Total Estimated Seasonal Load (lbs)	64 - 4,763	955 - 1,092	4,447	273 - 278	245,965 - 246,936	10.41 - 12.62	4.97 - 8.70	52.65	1,176 - 6,482	7.28×10^{12}

E. coli is in MPN/100mL for the EMC/MC and MPN for the loads.
*Where concentrations are reported at the detection limit, loads are presented as a range of possible values setting concentrations to either zero or the detection limit.

Table 2-7a. (Continued)

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Copper	Lead	Zinc	TPH	*E. coli*
Spring (Apr. – Jun. 2020)	Average Storm EMC (mg/L)	0.08 - 2.03	0.53	1.51	0.15	89	0.0046	0.0012 - 0.0026	0.0156	0.20 - 2.81	2,055
	Estimated Total Storm Load (lbs)	170 - 4,084	1,067	3,036	300	179,369	9.20	2.47 - 5.18	31.41	396 - 5,658	1.88×10^{13}
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.16 - 0.20	2.61	0.02 - 0.02	4.36	0.0000 - 0.0020	0.0000 - 0.0020	0.0085	0.00 - 2.70	223
	Estimated Total Baseflow Load (lbs)	0 - 1,737	143 - 174	2,265	17 - 20	3,787	0.00 - 1.74	0.00 - 1.74	7.41	0 - 2,345	8.79×10^{11}
	Total Estimated Seasonal Load (lbs)	170 - 5,821	1,210 - 1,241	5,301	316 - 319	183,156	9.20 - 10.93	2.47 - 6.92	38.82	396 - 8,002	1.96×10^{13}
FY2020 (Jul. 2019 – Jun. 2020)	Average Storm EMC (mg/L)	0.69 - 2.38	0.67 - 0.68	1.39	0.20	188	0.0068 - 0.0069	0.0033 - 0.0045	0.0276	0.49 - 2.91	2,746
	Estimated Total Storm Load (lbs)	3,672 - 12,578	3,541 - 3,581	7,337	1,044	997,556	35.82 - 36.37	17.73 - 23.74	146.08	2,610 - 15,413	6.59×10^{13}
	Average Baseflow MC (mg/L)	0.00 - 1.96	0.23 - 0.29	2.67	0.02 - 0.02	2.54 - 2.85	0.0009 - 0.0028	0.0000 - 0.0020	0.0113	1.20 - 3.05	163
	Estimated Total Baseflow Load (lbs)	0 - 6,106	703 - 913	8,312	56 - 68	7,911 - 8,867	2.71 - 8.72	0.00 - 6.23	35.11	3,747 - 9,510	2.30×10^{12}
	Total Estimated FY2020 Load (lbs)	3,672 - 18,684	4,244 - 4,494	15,649	1,100 - 1,112	1,005,467 - 1,006,423	38.53 - 45.08	17.73 - 29.97	181.19	6,357 - 24,923	6.82×10^{13}

*Where concentrations are reported at the detection limit, loads are presented as a range of possible values setting concentrations to either zero or the detection limit.

Table 2-7b. Seasonal and FY2020 stormflow concentrations and loads at the Pond-R Outfall station.*											
		BOD	**TKN**	**Nitrate + Nitrite**	**Total Phosphorus**	**TSS**	**Copper**	**Lead**	**Zinc**	**TPH**	***E. coli***
Summer (Jul. – Sep. 2019)	Average Storm EMC (mg/L)	0.00 - 3.47	0.92	0.20	0.09	11	0.0017 - 0.0022	0.0000 - 0.0020	0.0189	3.52 - 4.16	1.90×10^3
	Total Estimated Seasonal Load (lbs)	0 - 72	19	4	2	234	0.04 - 0.05	0.00 - 0.04	0.39	73 - 86	1.78×10^{11}
Fall (Oct. – Dec. 2019)	Average Storm EMC (mg/L)	1.92 - 3.37	0.34	0.01 - 0.05	0.07	2	0.0042	0.0000 - 0.0020	0.0265	3.50 - 4.49	1.92×10^2
	Total Estimated Seasonal Load (lbs)	24 - 42	4	0 - 1	1	25	0.05	0.00 - 0.02	0.33	44 - 56	1.09×10^{10}
Winter (Jan. – Mar. 2019)	Average Storm EMC (mg/L)	0.01 - 2.00	0.07 - 0.20	0.10	0.10	12	0.0024 - 0.0025	0.0000 - 0.0020	0.0140	0.00 - 2.70	1.30×10^2
	Total Estimated Seasonal Load (lbs)	0 - 25	1 - 3	1	1	151	0.03 - 0.03	0.00 - 0.03	0.18	0 - 34	7.41×10^9
Spring (Apr. – Jun. 2020)	Average Storm EMC (mg/L)	0.42 - 2.21	0.53	0.01 - 0.05	0.07	5	0.0035	0.0000 - 0.0020	0.0146	0.56 - 2.98	9.36×10^2
	Total Estimated Seasonal Load (lbs)	8 - 43	10	0 - 1	1	103	0.07	0.00 - 0.04	0.28	11 - 57	8.20×10^{10}
FY2020 (Jul. 2019 – Jun. 2020)	Average Storm EMC (mg/L)	0.25 - 2.29	0.36 - 0.42	0.06 - 0.09	0.09	9	0.0029 - 0.0029	0.0000 - 0.0020	0.0151	0.71 - 3.02	6.64×10^2
	Total Estimated FY2020 Load (lbs)	16 - 149	24 - 27	4 - 6	6	569	0.19 - 0.19	0.00 - 0.13	0.98	46 - 197	1.96×10^{11}

E. coli is in MPN/100mL for the EMC and MPN for the load.
*Where concentrations are reported at the detection limit, loadings are presented as a range of possible values setting concentrations to either zero or the detection limit.

Annual estimated pollutant loadings at the instream station decreased for all parameters during FY2020 compared to FY2019. This is largely due to the significantly high depth of rainfall and volume of stormflow in FY2019 in comparison to FY2020. The total discharge sampled at the instream site in FY2020 was less than the total discharge measured in FY2019 by 57%. The overall lower volume of runoff in the watershed produced lower pollutant loadings in the stream which may be attributed to the reduced storm activity and potentially the fifteen ponds being retrofitted. Annual estimated pollutant loadings at the pond outfall station decreased for all parameters during FY2020 compared to FY2019. The pond retrofit from a dry extended detention pond to a wet extended detention pond may have increased the pollutant removal efficiency of the facility in addition to the lower volume of stormflow in FY2020 in comparison to FY2019, causing the difference in pollutant concentration trends in comparison to the overall concentration decrease at the instream site. The total discharge sampled at the Pond-R site in FY2020 was less than the total discharge measured in FY2019 by 38%. Future monitoring will further determine if the retrofit improved pollutant loadings to the stream. The annual loading values for all parameters were within their respective historical ranges for both stations. For parameters that were detected in outfall samples during FY2020, the estimated contribution of Pond-R to the total loading of the watershed ranged from between 0.03% (Nitrate + Nitrite) and 0.74% (TPH).

2.2 BIOLOGICAL MONITORING RESULTS FOR PETER PAN RUN

Frederick County annually monitors biological conditions within Peter Pan Run's approximately 3-square mile catchment. Annual monitoring of Peter Pan Run began in June 1999 and continues to the present. The following is a summary of the biological data collected at the four Peter Pan Run stream monitoring stations in 2020 (Figure 1-2), with sites named PPAN-01 to 04 (also known as BUSL-201, 202, 103 and 104, respectively). Data from this year's survey, along with data from past years, have been compiled in Appendix A.

Benthic macroinvertebrate sampling and qualitative habitat assessments were conducted within the Maryland Biological Stream Survey (MBSS) Spring Index Period on March 9 and March 10, 2020. Quantitative geomorphic assessments surveys, including cross-sectional measurements, longitudinal profiles, and pebble counts, were conducted on March 9 and March 10, 2020. Summer sampling was conducted within the MBSS Summer Index Period on July 1 and July 8, 2020, and included *in situ* water quality measurements, further qualitative and quantitative physical habitat assessment, and electrofishing surveys.

The Quality Assurance Project Plan (QAPP) for Frederick County's biological and physical stream monitoring program in Peter Pan Run (Drescher 2020) was followed for all sampling. Following EPA guidelines, the QAPP documents a set of quality assurance and quality control procedures used for field and laboratory practices. The QAPP ensures the gathering of high quality, accurate data that will meet a study or project's objectives and goals. It also serves as a reference when questions arise about field or laboratory procedures.

Benthic macroinvertebrate and fish data were collected and used to calculate Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) scores for each of the four stations in the Peter Pan Run catchment. Fish and benthic IBI ratings for all sites were calculated in accordance with the Maryland Biological Stream Survey (MBSS) revised scoring methods

(Southerland et al. 2005; Appendix A, Tables A-4 and A-5). The Peter Pan Run sites are located in the MBSS highlands strata, thus the BIBI combined highland metrics and FIBI warmwater highlands metrics were calculated for each site. The IBI scores are divided into four classes as shown in Table 2-10.

Table 2-8. Narrative rating and score range for the Indices of Biotic Integrity used by the MBSS indices.

Rating	Range
Good	4.00 - 4.99
Fair	3.00 - 3.99
Poor	2.00 - 2.99
Very Poor	1.00 - 1.99

Peter Pan Run is listed as Use Class I-P in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to acceptable standards for the appropriate designated use listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 2-9). Specific designated uses for Use I-P streams include public water supply, water contact sports, fishing, the growth and propagation of fish (non-trout), and agricultural and industrial water supply. Use Class I-P streams receive regulatory protection from activities that may impact drinking water quality and general aquatic resources. Currently, there are no standards available for specific conductivity. However, Morgan et al. (2007) identified a critical threshold of impairment of BIBI scores for Maryland streams at 247 µS/cm.

Table 2-9. Maryland COMAR Standards

Parameter	Standard
pH (SU)	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No State standard
Turbidity (NTU)	Maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
Temperature (°C)	Use I - Maximum of 32°C (90°F) or ambient temperature of the surface water, whichever is greater; Use III - Maximum of 20°C (68°F) or ambient temperature of the surface water, whichever is greater; Use IV - Maximum of 23.9°C (75°F) or ambient temperature of the surface water, whichever is greater

Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3 – Water Quality

IBI scores for data collected in 2020 are summarized in Table 2-10. The biological communities in Peter Pan Run have experienced land use-related impacts due to previous agriculture and current residential development. It is likely that these benthic communities now have less inherent stability, and will therefore continue to fluctuate from year to year due to minor impacts or localized changes to the stream that otherwise would not lead to noticeable change (i.e., annual changes to BIBI narrative categories) in a minimally impacted watershed.

Table 2-10. Summary of 2020 results from Peter Pan Run using the MBSS 2005 IBIs

Station	Benthic IBI Score	Benthic IBI Rating	Fish IBI Score	Fish IBI Rating	MPHI Score	MPHI Rating
BUSL-201-T	1.50	Very Poor	4.67	Good	78.4	Partially Degraded
BUSL-202-T	1.50	Very Poor	4.67	Good	66.2	Degraded
BUSL-103-T	1.25	Very Poor	4.33	Good	71.1	Partially Degraded
BUSL-104-T	2.0	Poor	2.00	Poor	55.8	Degraded

Table 2-11. Summary of 2020 *in-situ* water quality results from Peter Pan Run

Station	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductivity (µS/cm)	Turbidity (NTU)
BUSL-201-T	3/9/2020	5.7	13.08	7.87	507.8	1.6
	7/8/2020	20.7	8.99	8.43	467.8	3.37
BUSL-202-T	3/9/2020	11.0	113.2	8.02	526.6	2.16
	7/8/2020	22.0	7.94	8.54	789.0	3.85
BUSL-103-T	3/10/2020	8.8	10.33	7.45	493.7	1.01
	7/1/2020	18.6	8.72	8.18	373.1	3.18
BUSL-104-T	3/10/2020	12.2	11.68	7.7	617.5	1.92
	7/1/2020	23.4	6.41	8.08	228.1	9.12

BUSL-201-T

This site is the most downstream site along Peter Pan Run with a drainage area of 1,585 acres. In 2020, the BIBI rating was 'Very Poor' (score of 1.50), which was a decrease from a 'Poor' rating in 2019. The slight decline in BIBI score between 2019 and 2020 can be attributed to a decrease in total number of taxa (27 in 2019 to 16 in 2020), as well as a decrease in percent of Tanytarsini midges (from 5.04% in 2019 to 0.57% in 2020). The FIBI score remained the same as in 2019 with a score of 4.67, and a rating of 'Good'. Slightly more fish were caught in 2020 than 2019; however it is noted that the number of fish observed each year is quite variable and has ranged from just under 400 to over 1,100 with no distinct pattern over time. In 2020, 41.08% of fish captured were considered 'Tolerant' species. The lowest percent of 'Tolerant' fish out of all years of monitoring was found in 2019, at just 32.59%. Eighteen species were encountered in 2020, the same as 2019 and the most of all sampling years. The MPHI score indicates this site is in a 'Partially Degraded' habitat condition. All WQ parameters in both spring and summer were within COMAR standards. Specific conductivity levels were above the 247 µS/cm threshold as described by Morgan et al. (2007) at both sampling events indicating chronic stress throughout the year for the benthic and fish communities.

BUSL-202-T
BUSL-202-T is located on Peter Pan Run upstream of BUSL-201-T and has a drainage area of 1,377 acres. In 2020, the BIBI score declined slightly to 1.50 from 2.00 in 2019 and dropped to a rating of 'Very Poor'. The decline is a result of a decrease in total taxa found from 24 in 2019 to17 in 2020, as well as a decrease in percent Scrapers. A constant FIBI score of 3.67, or 'Fair', was given to this site between 2014 and 2018. The score increased to 4.67, or 'Good', in 2019 and received the same score and rating in 2020. A decrease in the number of fish were caught in 2020 from 2019; however it is noted that the number of fish observed annually has varied and ranges from near 300 to over 1,000. The MPHI score increased slightly to a rating of 'Partially Degraded' in 2020. All WQ parameters in both spring and summer were within COMAR standards. The specific conductivity levels were slightly greater at this site than the downstream BUSL-201-T. Continued exposure of levels greater than 247 µS/cm as described by Morgan et al. (2007) is stressful for the biotic community and is likely impacting the BIBI scores at this site.

BUSL-103-T
This site is upstream of BUSL-202-T on an unnamed tributary to Peter Pan Run. The drainage area of this site is 557 acres. A slight decrease in BIBI score and rating occurred from 2019 to 2020 from 1.50 and 'Very Poor' to 1.25 and remained at 'Very Poor'. A large decrease in total number of taxa occurred, with 18 taxa found in the 2019 sample and only 8 taxa found in the 2020 sample. BUSL-103-T had in the same FIBI score and rating of 4.33 and 'Good' between 2019 and 2020. There were 2 less species present in 2020 than in 2019, and 48 fewer individuals. The number of fish observed annually varies and it appears that the 2020 results are in line with the past observations of between 400-600 individuals. The MPHI rating remained similar to 2019, with a rating of 'Partially Degraded'. All water quality parameters in both spring and summer with within the COMAR standards. Similar to the mainstem Peter Pan Run sites, both spring and summer specific conductivity values were greater than the threshold described by Morgan et al. (2007) indicating year round stress for the biological communities.

BUSL-104-T
This site is on an unnamed tributary to Peter Pan Run, which receives drainage from two stormwater ponds. The drainage area of BUSL-104-T is 65 acres, the smallest of the four sites monitored. The BIBI score increased from a score of 1.75 and rating of 'Very Poor' in 2019, to a score of 2.00 and a rating of 'Poor' in 2020. This increase was primarily caused by a decrease in percent Diptera. Only three species of fish were found and of the individuals encountered, 99% were considered tolerant. These factors resulted in a FIBI score of 2.00 and rating of 'Poor', the same score and rating as 2019. MPHI values indicate similar results with a rating of 'Degraded' for 2020. Although the biological and habitat scores were low, the water quality parameters were all within the COMAR standards while specific conductivity values were elevated during the spring assessment, greater than the threshold identified in Morgan et al. (2007).

2.3 PHYSICAL STREAM ASSESSMENTS

Physical stream conditions within Peter Pan Run in 2020 were generally similar to those in years past, although certain stream parameters are beginning to show a pattern of incremental change over time. A summary of historical and current data is provided in Appendix A. Field surveys are typically performed at least 24 hours after a major storm event and when conditions approximate baseflow. Representative site photographs can be found in Appendix A.

2.3.1 Longitudinal Profile Analysis

In December 2015, longitudinal profiles were established at each site. Benchmark pins were installed at the starting point (i.e., station 0+00) and to mark the end of the survey profile. Each profile is approximately 300 feet in length and encompasses the previously established cross-sections. Both left and right bank cross-section pins were surveyed into the longitudinal profile to obtain relevant elevations for tying in the cross-sections to the profile. Profiles were established along the center of the channel and included a survey of breakpoints in and between bed features, as well as delineation of riffles, runs, pools, and glides. A survey of the bankfull elevation (where discernible), top of bank, and water surface was also performed. Longitudinal profile overlays for all four sites can be found in Appendix A.

As monitoring of the sites' longitudinal profiles only began in 2015, few major changes have occurred to date. Although bed features at each of the four sites may have shifted upstream or downstream by a few feet in some cases, the channel remained stable between 2015 and 2019.

At BUSL-103 the pool at the beginning of the longitudinal profile has shifted downstream and increased in depth between 2019 and 2020. The pool nearest station 1+59 has remained the same between 2019 and 2020. The greatest change in the profile is above the bedrock step at station 1+60 where bed erosion has occurred all the way up to the downed tree near station 2+30. This tree was first noted in 2017 and the scour pool has increased every year since then. In April 2000, slope at BUSL-103-T decreased significantly as a result of channel elevation changes associated with a sewer line crossing between the station and its confluence with Peter Pan Run. Slope then increased in 2005 and 2006. From 2007 through 2017, slope increased or decreased slightly from year to year; however, in the past five years, slope has remained consistent between 0.9% and 1.0%.

The BUSL-104-T profile depicts that the pool near station 0+50 has continued to scour out while the pool near 1+75 has increased in depth from 2019 where sediment began accumulating. The debris jam upstream of the pool has increased the deposition of material causing the bed elevation to increase between stations 1+80 and 2+25. The bed elevation remained consistent from 2019 to 2020 from station 2+25 to 3+00. Slope at BUSL-104 has remained stable at approximately 1.4% for the past 14 years.

The longitudinal profile of BUSL-201-T demonstrates that some of the pools are continuing to accumulate sediment while some are now beginning to scour and deepen. Increased deposition on point bars was noted in 2019 and continues in 2020, which caused an increase in sinuosity, which in turn caused features to move slightly upstream. The pool originally located nearest station 1+25 in 2015 decreased in depth in 2018 but increased in depth in 2019 and has remained the same in 2020. The pool around station 1+70 accumulated sediment in 2018 but has since increased in depth and length in 2019 and 2020 with a slight decrease in depth in 2020. The pool located near station 2+75 has seen a major increase in deposition between 2018 and 2019 with a one-foot decrease in depth and 10-foot decrease in length. In 2020 this pool has begun to deepen and migrate upstream.

Stream gradient has been mostly stable at BUSL-201-T during the past ten years, with a slight increase in 2020 from 0.58% to 0.71%.

At BUSL-202-T the greatest change between 2018 and 2019 was the deepening of the pool at station 0+20. The pool had lengthened some but the most significant change is the increase in depth of over one foot between the two years. In 2020 the same pool has filled in with 1.2 ft of sediment when compared to 2019. Besides the changes in the previously noted pool, few changes along the thalweg occurred between 2019 and 2020. The pool at station 1+05 in 2015/2016 became a riffle in 2017 and continues to be a riffle in 2020. The pool at station 1+60 has filled in by about 0.7 ft of sediment. The pool near station 2+40 has deepened slightly. In 2001, BUSL-202-T appeared to have aggraded. Since that time and continuing through 2020, stream slope has remained stable between 0.4% and 0.5%.While these vertical changes along the longitudinal profile demonstrate the amount of sediment moving through the stream, the cross section comparisons discussed below show the long-term lateral changes in the system.

2.3.2 Cross Section Analysis

Cross-sectional surveys were conducted at monumented locations at each station; overlays of the cross sections are located in Appendix A, which includes the cross section data from 1999 to 2020 and photos of the cross sections can be found in Appendix A. The only exception is at BUSL-201, where data from 1999-2004 was excluded from the analysis. Monumented locations at all cross sections were not established until 2004, and top of banks were not clearly defined at BUSL-201, making the overlay not accurate from 1999 to 2004.

Only minor changes to the channel occurred at BUSL-103-T between 2019 and 2020. While left and right bank erosion is observed from 1999 to 2016, only slight changes were observed between 2016 and 2020. The channel thalweg has increased in depth between 2019 and 2020 with a mean depth of 1.3 feet from 1.1 feet in 2019. This increase in depth caused an increase in cross sectional area and estimated discharge in 2020 A slight break in bank slope occurs on the right bank, which is a bankfull indicator. From 2015 to 2016, the right side of the channel downcut 0.75 feet, removing the depositional material which accumulated in 2014 and 2015. In 2017, the left side of the channel scoured slightly and the right bank experienced some accumulating sediment just above the water surface, narrowing the channel by 0.5 feet. The channel width increased only slightly between 2019 and 2020 by 0.3 feet.

Cross-sectional surveys of BUSL-104-T suggest only minor alterations within its channel. Previous data had indicated that BUSL-104-T was downcutting slightly on the left bank, as evidenced by increased values for stream slope and average depth. Conditions at the site were stable from 2008 to 2016, however, in 2017 and 2018 the thalweg moved towards the left bank. In 2020 the thalweg is along the right of the channel as sediment has built up on the left bank and the right bank experienced minor downcutting. The left bank is becoming more vertical up to the bankfull elevation, where the bank slope then becomes less steep continuing to the top of bank. The right bank remains raw and vertical and has continued to erode slightly with an undercut forming ¾ up the bank.

The cross-sectional survey at BUSL-201-T illustrates channel widening, as it expanded by 3.0 feet to the left between 1999 and 2005, and by an additional 1.9 feet between 2005 and 2009. The left bank at BUSL-201-T continues to erode each year, having scoured an additional foot between 2013 and 2019. In 2020 the left bank continues to scour while the top of bank is continuing to slump. A large gravel bar has filled in the center and the right half of the channel. Between 2015 and 2017, material continued to deposit, increasing bar height by 0.1 feet. In 2017, the bar shifted to the left as the right side of the channel underwent significant scour of about 1.05 feet, creating a new thalweg on the right side of the channel. These conditions were also recognized in the 2018 survey, where the thalweg was more so along the right bank. In 2019 however, major deposition of one foot occurred. A downed tree on the right bank slope has begun to erode behind the tree causing an increase in bank erosion on the right bank. Both right and left banks were almost vertical. An increase in deposition beyond the right top of bank in the flood plain was observed in 2019 with the right bank monument being buried 5 inches under sediment in 2020.

At BUSL-202-T, material was removed from the cross-section by downward scouring between 2003 and 2008. From 2009-2011, a fallen tree was jammed at the cross-section location. Approximately two feet of bed material was scoured out below the log jam. After the log was dislodged and moved down-stream of the cross-section in 2012, depositional material filled in the scoured area at the cross-section. Between 2013 and 2015, streambed erosion and deposition appeared to have stabilized, however, from 2015 to 2016 slight aggradation was noticed along the left bank and the right side of the stream channel scoured down 0.95 feet. In 2017, the left side of the channel scoured slightly (0.4 feet) and the right side continued to scour down by an additional 0.25 feet from 2016. Between 2017 and 2018 almost 0.5 feet of deposition occurred in an area along the left back of about 2.5 feet. In 2019, the 0.5 feet of deposition along the left back from 2018 has been scoured while the pool on the right side of the channel has seen deposition of 0.5 feet of material. Very little change occurred between 2019 and 2020 as the thalweg is still along the right bank, with vertical banks until the bankfull elevation, then less steep banks up to the top of bank. Bank erosion has marginally continued on the right bank.

2.3.3 Particle Distribution Analysis

Representative Wolman pebble counts were conducted at each cross section location from 1999 to 2020 (see Table 2-12 for stream particle categories). Particle size distribution overlays from 1999 to 2020 are available in Appendix A and Table 2-13 compares the D_{16}, D_{50}, and D_{84} of all pebble count data.

Table 2-12. Stream particle grain-size classifications			
		Median (mm)	**Range (mm)**
SILT/CLAY	Silt/Clay	0.01	< 0.062
SAND	Very Fine	0.02	0.062 - 0.13
	Fine	0.19	0.13 - 0.25
	Medium	0.38	0.25 - 0.50
	Coarse	0.75	0.50 - 1.0
	Very Coarse	1.5	1.0 - 2
GRAVEL	Very Fine	3	2 - 4
	Fine	5	4 - 6
	Fine	7	6 - 8
	Medium	10	8 - 11
	Medium	14	11 - 16
	Coarse	20	16 - 22
	Coarse	28	22 - 32
	Very Coarse	40	32 - 45
	Very Coarse	56	45 - 64
COBBLE	Small	80	64 - 90
	Small	109	90 - 128
	Large	154	128 - 180
	Large	218	180 - 256
BOULDER	Small	309	256 - 362
	Small	438	362 - 512
	Medium	768	512 - 1024
	Large	1500	1024 - 2048
	Very Large	3072	2048 - 4096
BEDROCK	Bedrock		> 4096

At BUSL-103 the median particle size (D_{50}) has ranged from 16mm to 40mm between 2015 and 2020, which ranges between Medium and Very Coarse Gravel. A slight increase in larger material was observed in 2020, which is evident in the particle distribution overlay (Appendix A). The D_{84} in 2020 was 86mm, which is similar to the last 6 years. Overall although minor shifts in the distribution have occurred, the particle size has remained relatively stable over time.

At BUSL-104 the D_{50} remained in the Coarse Gravel category from 2002 to 2017, but in 2018 the D_{50} dropped to 1.9mm, which is in the Very Coarse Sand category. In 2019, the D_{50} increased to 14mm which is similar to what it has been prior to 2018. The D_{50} in 2020 remained increased from 2019 to 20mm and in the Coarse Gravel category. The D_{84} increased from 64 mm in 2019 to 79 mm in and falls within the Small Cobble range.

At BUSL-201 the D_{50} in 2020 was 25mm, falling in the Coarse Gravel category. This is similar to previous years, where the D_{50} primarily falls in the Medium or Coarse Gravel category. The particle overlay is located in Appendix A, and shows that the particle distribution has been stable from 1999 to 2020.

At BUSL-202 the D_{50} in 2020 was 26mm, which falls in the Coarse Gravel category. This is an increase from the 2016 and 2017 D_{50} (8.8mm and 2.8mm respectively) but is similar to 2018 and 2019 D_{50}. While the range in D_{50} over the monitoring years is slightly greater here than at the other cross sections, the D_{50} remains in the Gravel category.

Table 2-13. Cross Section Particle Distribution Comparison

METRIC	BUSL-103							BUSL-104						
	'99	'15	'16	'17	'18	'19	'20	'99	'15	'16	'17	'18	'19	'20
D_{16}	0.084	10	4	1.4	1.3	6.8	1.7	0.37	4.9	1.2	1.3	0.21	0.38	1.7
D_{50}	8.6	40	20	16	35	25	29	10	17	13	12	1.9	14	20
D_{84}	50	86	48	43	99	63	86	50	83	35	36	73	64	79

METRIC	BUSL-201							BUSL-202						
	'99	'15	'16	'17	'18	'19	'20	'99	'15	'16	'17	'18	'19	'20
D_{16}	1.4	1.2	16	2.6	8	2.7	14	0.06	1.7	0.66	0.06	6	3.5	14
D_{50}	9.9	19	29	13	28	12	25	8.2	34	8.8	2.8	27	27	26
D_{84}	34	45	50	48	74	45	31	27	71	16	12	72	44	43

2.4 INTEGRATED ANALYSIS OF FIELD RESULTS

Frederick County has collected and analyzed considerable data to assess physical, chemical, and biological conditions in the Peter Pan Run watershed since monitoring began in May 1999. During that time, land clearing and related development activities have occurred in phases, with construction starting in new sections as others are completed. Additionally, natural variation in precipitation patterns has occurred over the study years, with three very dry (FYs 1999, 2002, and 2007) and eleven very wet years (FYs 2000, 2003, 2004, 2010, 2012, 2013, 2014, 2015, 2018, 2019, and 2020).

These development and weather factors present a complex set of variables affecting conditions within the study area. While these factors should be considered in drawing conclusions about the stressors affecting stream conditions, data generally indicate that there are some adverse effects associated with construction and development within the catchment. It should also be noted that the on-going development is not the only factor influencing conditions within the study area; based on pre-construction, baseline-monitoring data, the effects of historical and pre-development land use activities within the catchment are also evident.

2.4.1 Hydrology and Water Chemistry

Pollutant loading estimates provide an illustration of the total quantity of pollutants transported out of a watershed, but can vary widely on an annual basis due to variability in weather conditions and stream discharge. For this reason, the determination of trends in pollutant loading is challenging. To determine whether pollutant levels in Peter Pan Run have been changing significantly since the beginning of PUD construction and required chemistry monitoring, statistical analysis was performed on the individual storm EMC data from FY1999 to present. A Kendall's Tau correlation for trends (Kendall 1948) on the individual storm EMC data showed statistically significant upward trends over time for TKN ($\tau = 0.125$, $p = 0.009$) and TPH ($\tau = 0.126$, $p = 0.032$) and statistically significant downward trends over time for combined nitrate and nitrite ($\tau = -0.239$, $p = <0.0001$) and copper ($\tau = -0.121$, $p = 0.010$) at the instream station (Figures 2-15 through 2-18). The trend of increasing TPH over time at the instream station became significant in FY2020.

For both baseflow and stormflow conditions at the instream station, concentrations of nitrogen measured as combined nitrate and nitrite have nearly always been greater than 1 mg/l, (Figure 2-15). This concentration level indicates nitrogen contributions from anthropogenic sources (Roth et al. 1999). Individual storm EMCs for copper and combined nitrate and nitrite have gradually, but significantly, declined since 1999 as shown by the Kendall's Tau-b statistical analysis. Storm EMCs for TKN, conversely, have gradually increased. The nitrate and nitrite reduction and TKN increase may be the result of gradually increasing impervious cover in the watershed, which reduces groundwater, the primary contributor of nitrate and nitrite input to streams, and increases urban stormwater runoff, a major source of TKN or ammonia and organic nitrogen (EPA, 2015). As in the case of TSS, lead, and zinc, EMCs at the instream station have been variable with no statistically significant trend (Figures 2-16, 2-17, and 2-18).

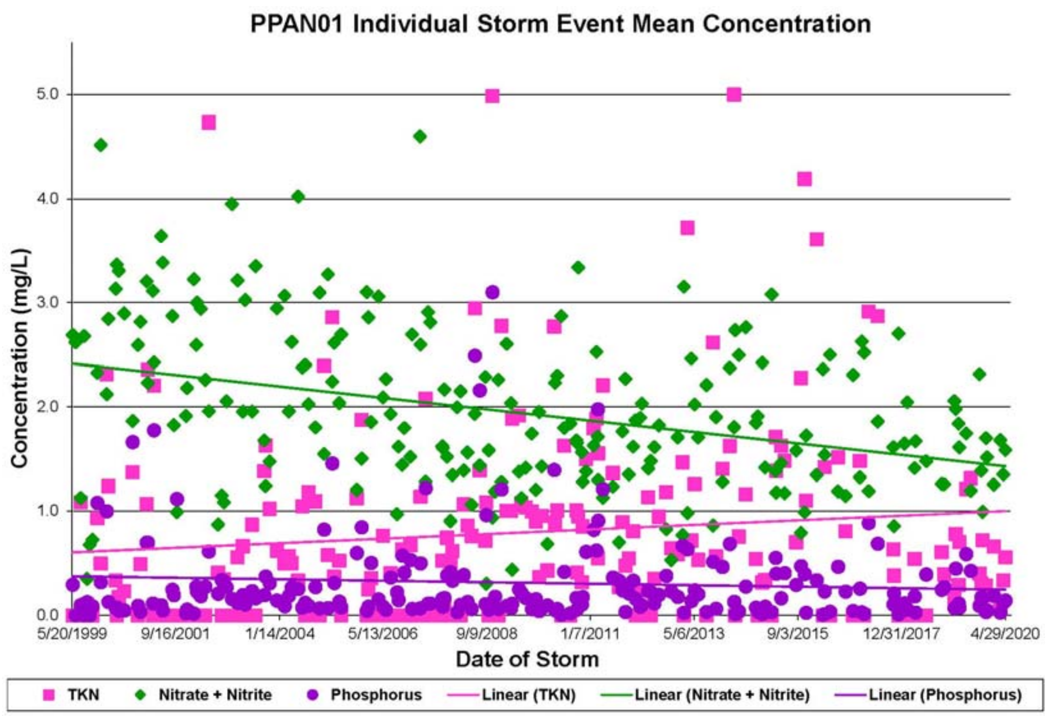

Figure 2-15. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2020) at the instream station. Values below detection limit are set to zero.

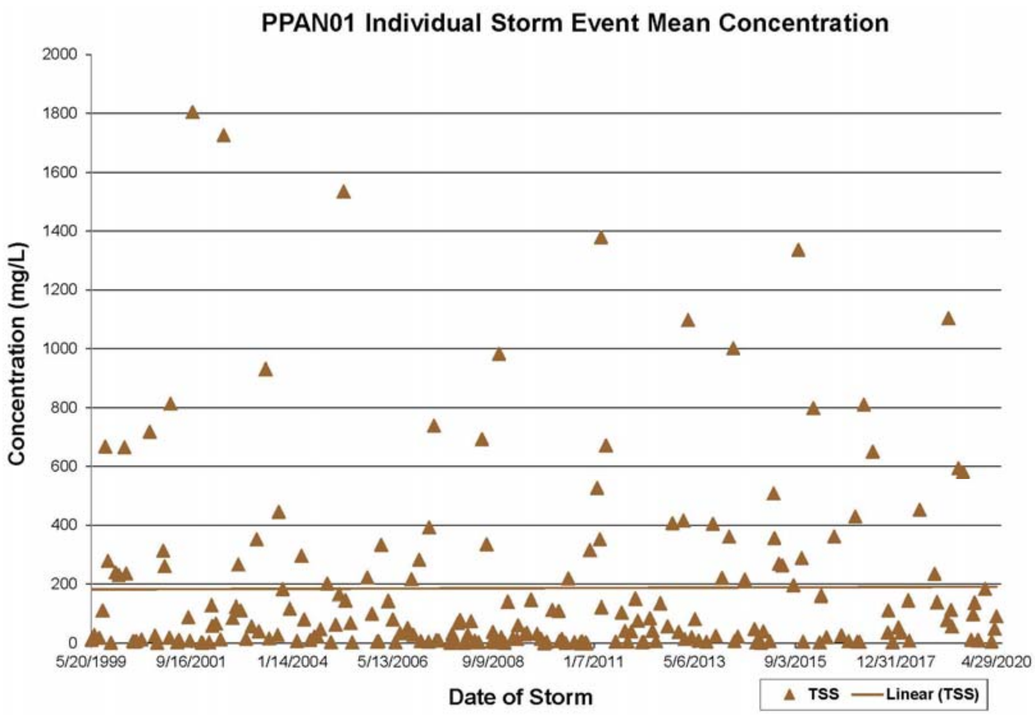

Figure 2-16. Storm event mean concentrations for TSS (May 1999 to July 2020) at the instream station

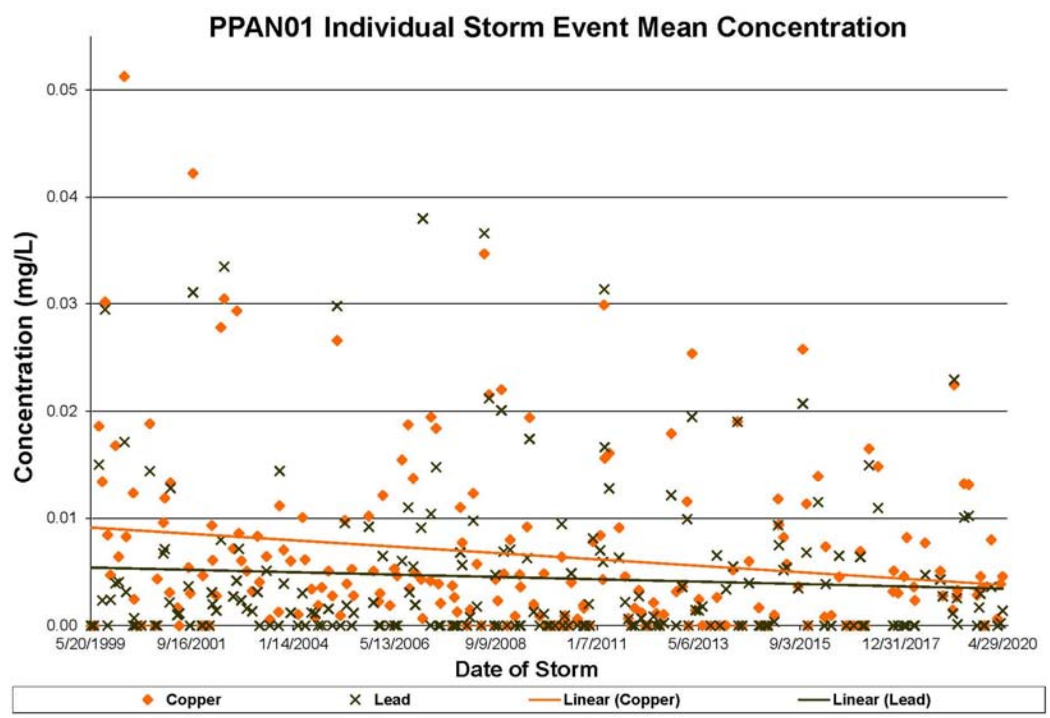

Figure 2-17. Storm event mean concentrations for copper and lead (May 1999 to July 2020) at the instream station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

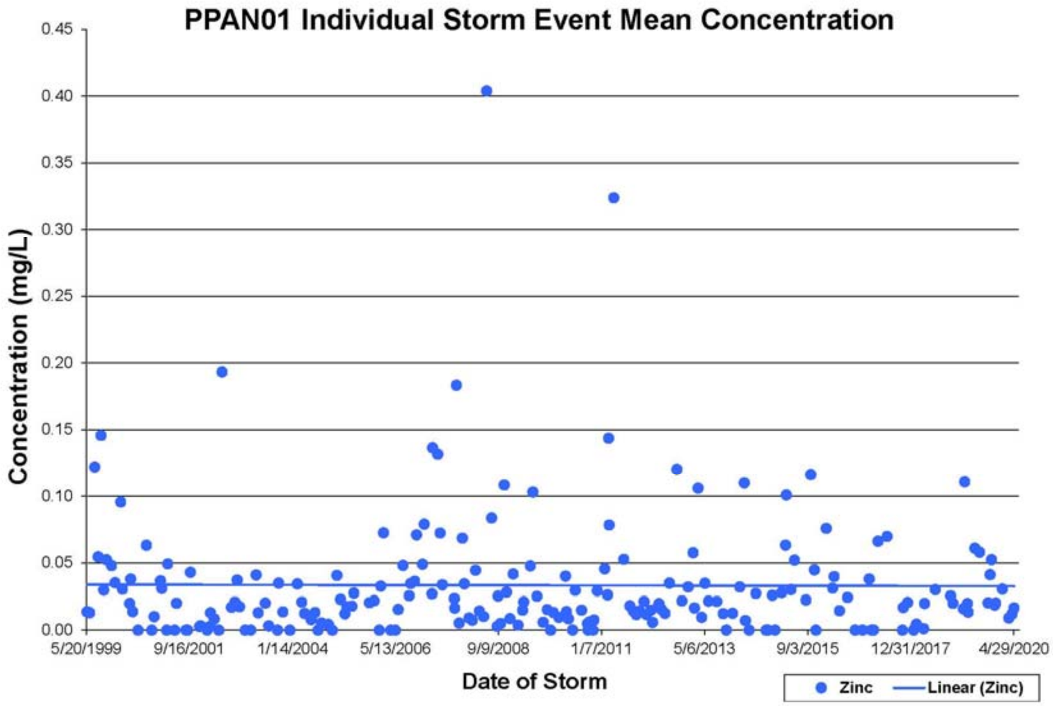

Figure 2-18. Storm event mean concentrations for zinc (May 1999 to July 2020) at the instream station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

Individual storm EMC data showed statistically significant downward trends over time for BOD (τ = -0.161, p = 0.003), TKN (τ = -0.141, p = 0.007), nitrate and nitrite (τ = -0.171, p = 0.001), phosphorus (τ = -0.278, p = <0.0001), copper (τ = -0.129, p = 0.013), lead (τ = -0.144, p = 0.0020), and zinc (τ = -0.127, p = 0.015) and a statistically significant upward trend over time for TPH (τ = 0.243, p = <0.001) at the outfall station (Figures 2-19 through 2-22). The trend of increasing TPH over time at the Pond-R station became significant in FY2020. TSS measured at the outfall station strongly correlated with BOD (τ = 0.174, p = 0.001), TKN (τ = 0.269, p = <0.0001), phosphorus (τ = 0.163, p = 0.002), copper (τ = 0.266, p = <0.0001), lead (τ = 0.247, p = <0.0001), and zinc (τ = 0.128, p = 0.014), indicating that metals and nutrients are bound to suspended soil particles. TKN EMCs have decreased over time inversely to the TKN instream EMCs while combined nitrate and nitrite has decreased over time in concurrence with the stream. Copper EMCs at the outfall station have decreased concurrently with the instream station. BOD, phosphorus, lead, and zinc EMCs have followed decreasing trends at the outfall station in comparison to no statistically significant trends at the instream station.

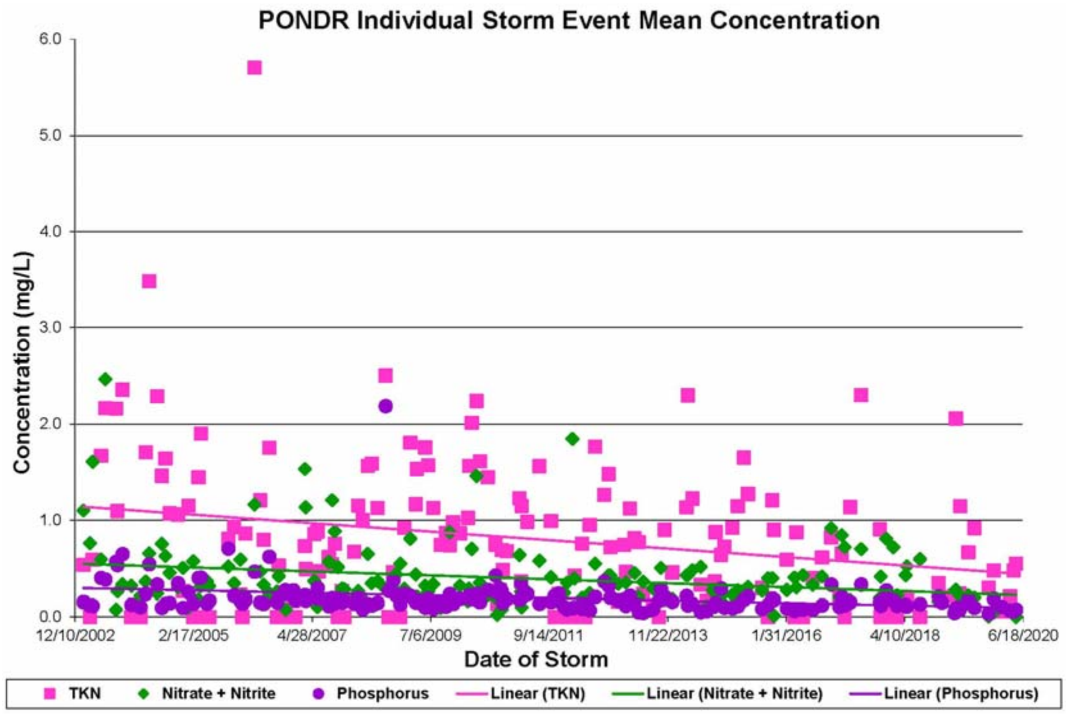

Figure 2-19. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2020) at the outfall station. Values below detection limit are set to zero.

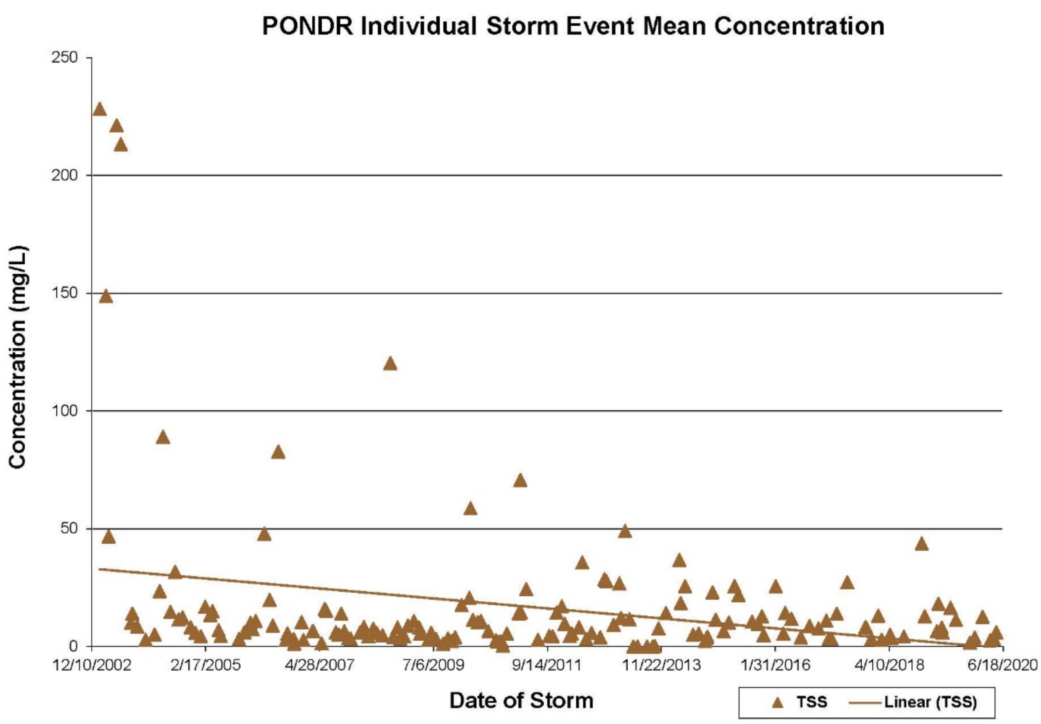

Figure 2-20. Storm event mean concentrations for TSS (May 1999 to July 2020) at the outfall station

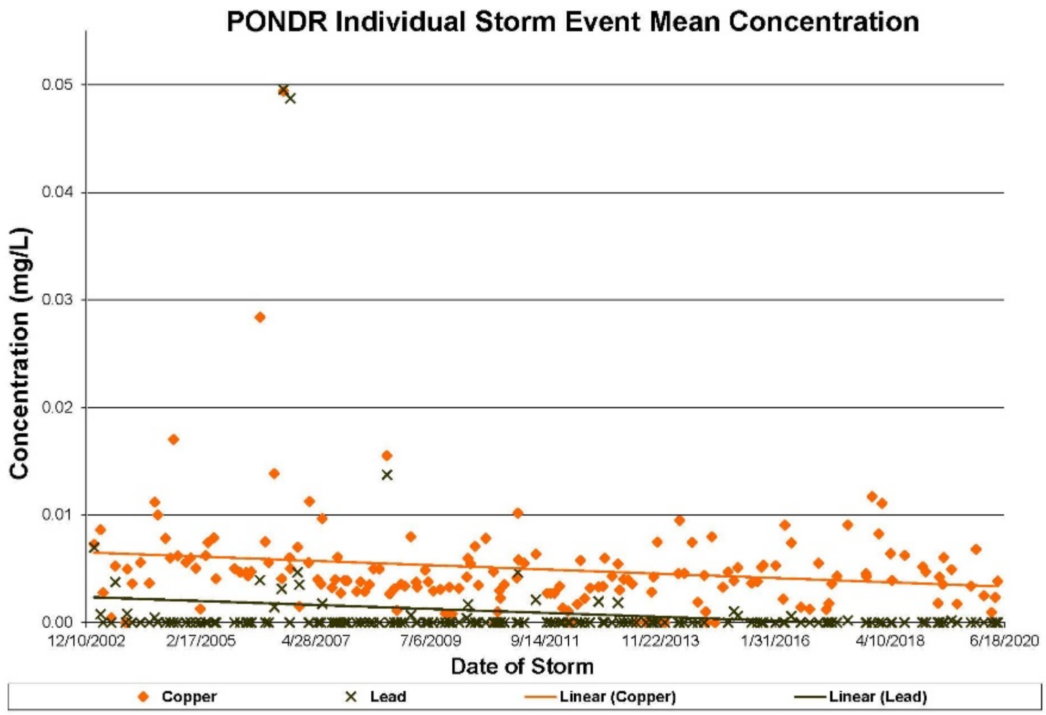

Figure 2-21. Storm event mean concentrations for copper and lead (May 1999 to July 2020) at the outfall station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

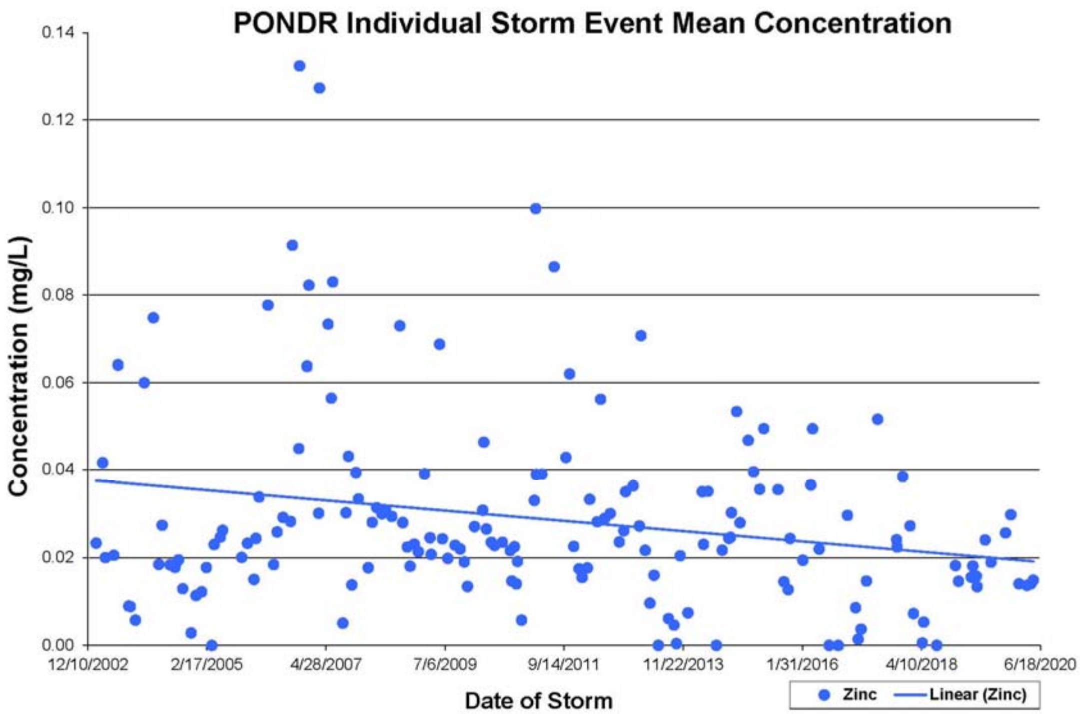

Figure 2-22. Storm event mean concentrations for zinc (May 1999 to July 2020) at the outfall station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

2.4.2 Biological Indicators

Dating back to 1999, BIBI and FIBI scores during the pre-construction period fell short of the top category for biological integrity (e.g., FIBI scores were in the 'Poor' to 'Fair' range). This likely indicates that prior to development the agricultural land use within the watershed was having a negative impact on the stream biota. Three of the four site's (BUSL-201-T, BUSL-202-T and BUSL-103-T), benthic scores decreased in 2020 when compared to 2019 scores, and ratings this year were 'Very Poor' at those same three sites (BUSL-201-T, BUSL-202-T and BUSL-103-T) and 'Poor' at BUSL-104-T. These results fall below the long-term average scores, which have oscillated between the 'Fair' and 'Very Poor' categories at BUSL-201-T, BUSL-202-T, and BUSL-103-T, and between the 'Poor' and 'Very Poor' categories at BUSL-104-T (Figure 2-23). During a period of very active construction in 2003 and 2004, BIBI scores dropped to Poor or Very Poor at all four sites. These four sites all show a high year-to-year variability in the BIBI scores, with sites frequently changing up to 1.5 IBI units over a one to two year period (Figure 2-23). The continued year-to-year fluctuations of the benthic IBI scores (between the 'Fair' and 'Very Poor' rating categories) reflect the noted changes in physical habitat, in particular the highly mobile substrate and bed features. The stream is capable of providing adequate habitat for the benthic community, however this habitat is vulnerable to periodic disruption due to flashy flows and excessive sediment loads moving through the system and periodically covering benthic habitats. Changes in the watershed landscape, such as the conversion of forest to impervious surface, leave a stream less able to withstand stressful climatic conditions, such as drought or frequent high flow conditions. Direct infiltration is reduced and lower baseflows leave stream biota vulnerable to increased temperature, decreased dissolved oxygen levels and flow-related fluctuations in available habitat. The elevated conductivity levels measured at all sites during both the spring and summer sampling visits suggest that the organisms living at these sites are subjected to osmotic difficulties due to high concentrations of dissolved solids.

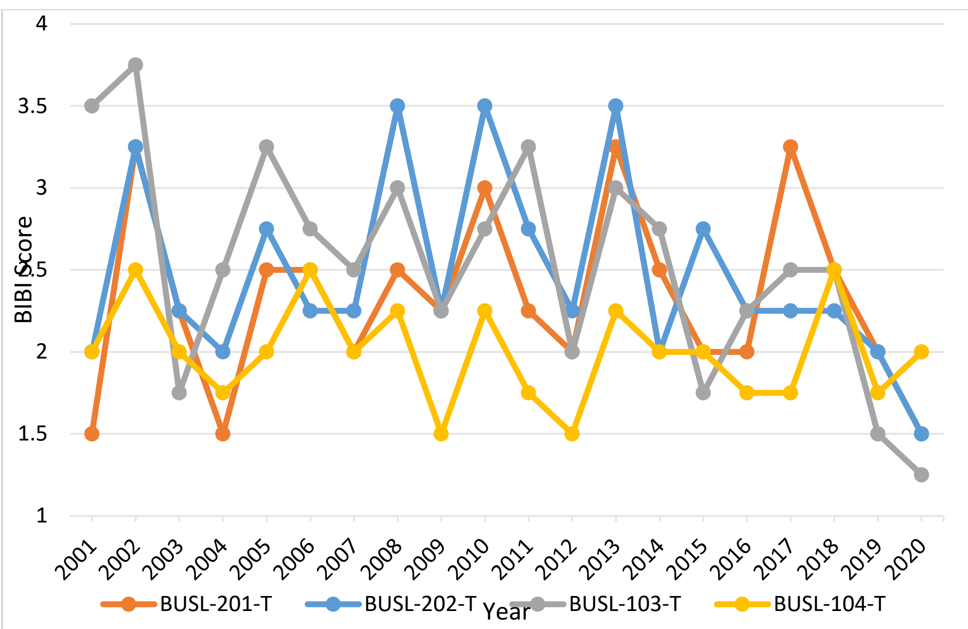

Figure 2-23. BIBI Score from 2001-2020

This year's FIBI score ratings were 'Good' for BUSL-201-T, BUSL-202-T, BUSL-103-T and 'Poor' for BUSL-104-T (Figure 2-24). Over the 20 years of sampling, FIBI scores have remained relatively constant with minor fluctuations between years. BUSL-201-T, BUSL-202-T and BUSL-103-T have fluctuated between a rating of 'Good' and 'Fair' while BUSL-104-T has remained in the 'Poor' to 'Very Poor' category. Variability in FIBI scores over the period of record for these sites is much lower than for the BIBI scores. FIBI scores have usually varied by less than 1 IBI unit from year to year. Since fish are more mobile and somewhat less dependent on bottom substrate for cover than macroinvertebrates, are slightly more tolerant of frequent disturbances to the stream bed and depositional processes.

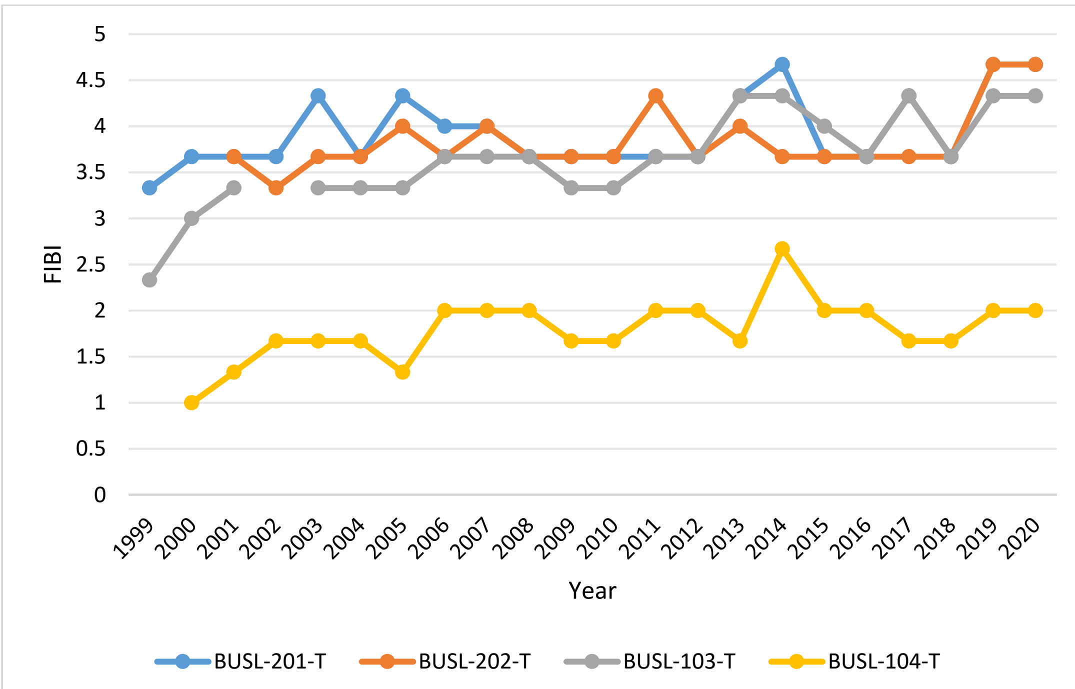

Figure 2-24 FIBI Score 1999-2020

2.4.3 Physical Habitat

Physical habitat, especially increased bank erosion and sediment deposition, is the most obvious sign that the stream has suffered negative impacts as a result of disturbance due to upstream land use conversion to suburban development. While the most intensive phases of construction in the Urbana PUD have been completed, and the amount of construction in the watershed was minor this year relative to previous years, no significant signs of recovery were noted in the habitat data. Physical habitat scores have largely remained similar at all sites over the monitoring years, with the fluctuations observed likely the result of depth-dependent habitat metrics or the subjective nature of the physical habitat scoring methods. The channel does not presently appear to be morphologically stable. Historical and pre-development land use activities within the catchment also continue to impact current stream conditions (Figure 2-25).

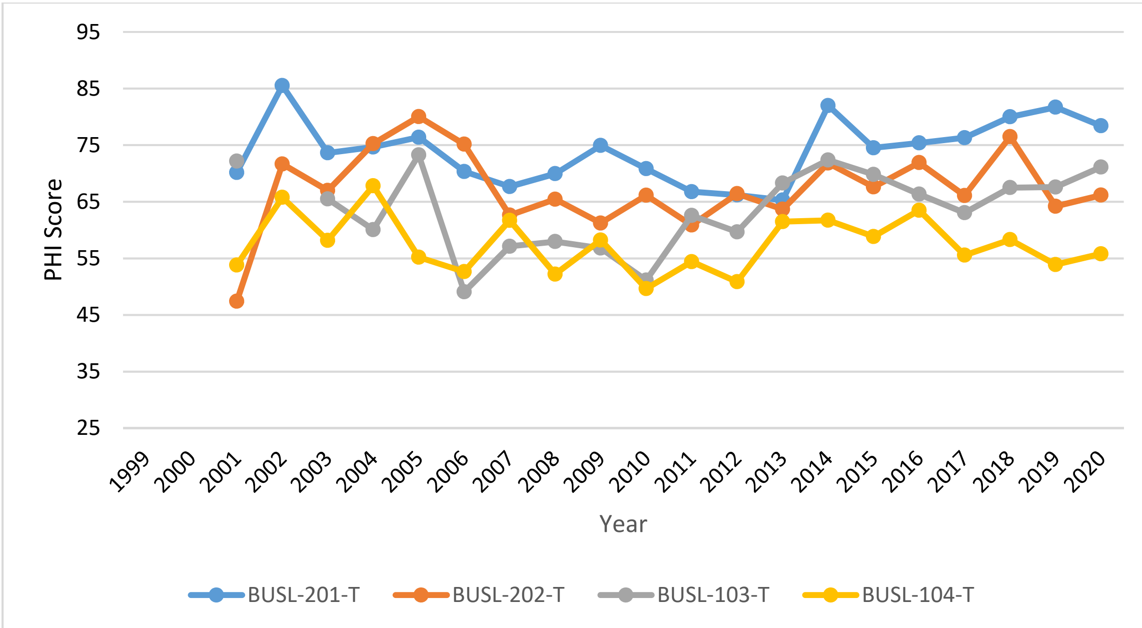

Figure 2-25. PHI Score from 2001-2020

2.4.4 Plans for Future Long-Term Monitoring

In FY2018, Frederick County invested significant resources in replacing all of the automated storm event sampling equipment in October 2017. As discussed earlier, many watershed stormwater BMPs were retrofit in 2018 and 2019, future monitoring will determine the impact of those retrofits on stormwater quality and channel stability. No significant changes are anticipated to the monitoring elements described in Table 2-14.

Table 2-14. Summary of changes to Frederick County's long-term monitoring efforts

Monitoring Effort	Location	Plans
Chemical Storm Event Monitoring	Peter Pan Run: instream and outfall stations	No change to current storm event monitoring procedures. Will continue to sample 8 events (2/quarter) based on the County's NPDES permit.
Biological and Physical Monitoring	4 stream stations in Peter Pan Run	No change to current monitoring procedures. Will continue with annual biological and physical monitoring, and surveying of geomorphic cross-sections.
Stormwater Management Assessment	4 stream stations in Peter Pan Run	Survey geomorphic longitudinal profiles beginning in FY2016, as well as hydrologic and/or hydraulic modeling completed in FY2018, the 4th year of the permit. No changes planned for the future.

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APPENDIX A

SUMMARY OF BIOLOGICAL AND PHYSICAL MONITORING DATA FOR PETER PAN RUN

APPENDIX B

METHODS FOR ESTIMATING POLLUTANT LOADING IN PETER PAN RUN

Methods for Estimating Pollutant Loading in Peter Pan Run

Calculation factors used to estimate pollutant loadings at Peter Pan Run and at Pond-R Outfall were determined as follows:

- Stage data were measured from July 1, 2019 to June 30, 2020 by an ISCO 730 Bubbler Flow Module. Flow rate data (in cfs) were estimated by comparing stage data to a rating curve specific to each station. The rating curve at the instream station was formed using field stage (ft) and discharge (cfs) measurements taken between 2017 and 2018. A stilling well for the instream station instrument was installed on November 26, 2018 and a new rating curve was established with field measurements. The rating curve at the outfall station was formed using Manning's equation with a roughness coefficient of 0.013, pipe slope of 0.0213 ft/ft, and pipe diameter of 3.5 ft. Additional flow measurements were taken in the field at the instream station during FY2020 and the rating curve was updated. The in stream stilling well rating curve does not fit stage values of less than 0.43 feet well. Therefore, a second curve was generated for the instream station to better match stage values of less than 0.43 feet. All rating curves followed second order polynomial equations with R^2 values of 0.5 for the instream station high stage curve, 0.99 for the instream station low stage curve, and 1.00 for the outfall station. In between values were estimated via interpolation. The rating curves were used to estimate the discharge in cubic feet per second from the stage values measured at both stations.
- At the instream station, stormflow and baseflow were separated by noting where the hydrograph increased due to rain and then decreased to a base level. Stormflows were considered flows that occurred during periods of elevated level due to rain. Baseflows were the flows measured at all other times. Baseflow was not observed during FY2020 at the outfall station. All flow at the outfall station was considered stormflow.
- Flow volumes were calculated for each reading by averaging the flow (cfs) over the five-minute interval and then multiplying the averaged flow by 5 minutes using the proper conversions.
- The average flow rates, total flow volume, and days of flow for stormflow and baseflow were calculated for each season and the reporting year. The proportion of discharge characterized as baseflow and stormflow are given in Table B-1.

Table B-1. Proportion of discharge characterized as baseflow and stormflow at both Peter Pan Run stations FY2020

Location	Percent Baseflow	Percent Stormflow	Days Baseflow	Days Stormflow	Volume Baseflow (ac-ft)	Volume Stormflow (ac-ft)
Instream*	68%	32%	248	118	1,178	1,916
Outfall*	0%	23%	0	82	0	24

*Due to Flow Module malfunction at the stations, erroneous data were corrected based on assumptions derived from the accurate periods of record.

- With the total volume of water calculated per storm event, season, and the reporting year, the total pollutant loads were calculated by multiplying the EMC or MC by the cumulative volume of water over the identified period and then converted to pounds.

- Some pollutant concentrations were below the detection limit for the method used to analyze the pollutant in the sample. In these cases a range of values are offered. The lower value was calculated assuming the pollutant concentration was zero. The higher value was calculated assuming the pollutant concentration was the concentration of the detection limit.