5.0 DISCHARGE CHARACTERIZATION

5.1 FREDERICK COUNTY'S LONG-TERM MONITORING PLAN

In May 1999, the County initiated a long-term monitoring program to monitor and assess the effects of stormwater runoff stemming from development. With MDE's approval, the County selected Peter Pan Run as the study stream because of development of The Villages of Urbana planned unit development (PUD) within its headwaters. Peter Pan Run is located within the Bush Creek watershed, the County's top-priority watershed, which flows westward into the Monocacy River near Frederick Junction.

The Villages of Urbana is a mixed-used 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. Development within the PUD is anticipated to continue until approximately 2010, and accounts for most of the growth within the Urbana Planning Region (FCDPZ 2004). Estimates in the County's regional plan indicated that between 200 and 300 new residential lots would be recorded each year in the Urbana PUD. During 2009, construction of the PUD continued within certain sections, while many other sections have been completed and are occupied by residents. In addition, substantial road construction has occurred, with the realignment of Rt. 355/80 in the southern portion of the catchment. Figure 5-1 provides 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 construction.

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 monitoring 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 5-2). In particular, monitoring is focused on the common long-term problems often associated with residential development that could occur within Peter Pan Run, including 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 down storm drains.

Frederick County has compiled data to characterize the catchment upstream of the Peter Pan Run instream monitoring site and the Pond R outfall site. Data on catchment area, land uses, and site location are listed in Appendix C, and the complete database is included on the accompanying CD. Land use was derived from draft 2007 Maryland Division of Planning GIS data, which is the most recent data available. At present, the County's SWM database indicates that 14 structural SWM facilities (11 extended dry detention ponds, two sand filters, and one infiltration trench)

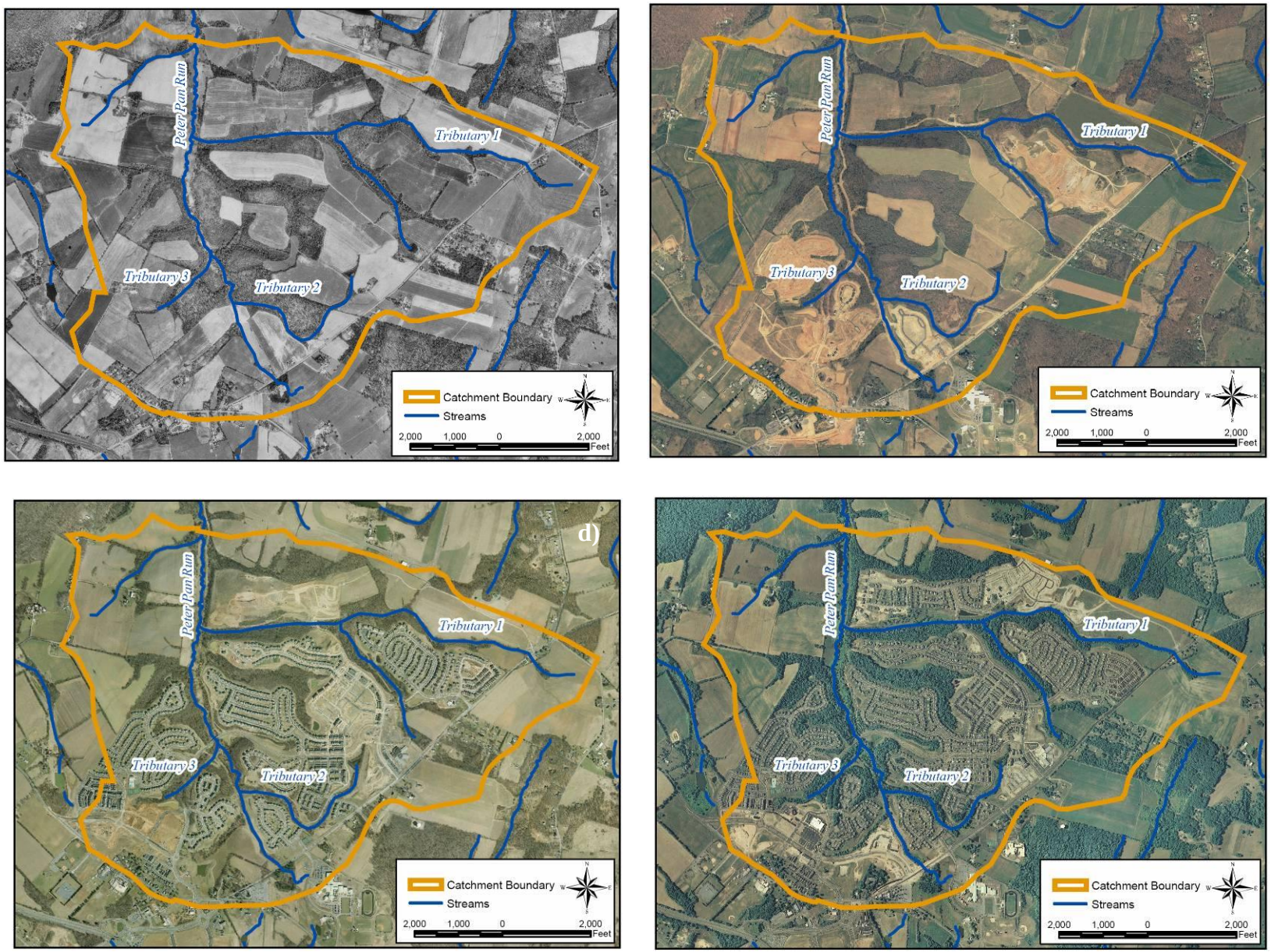

Figure 5-1. Aerial photographs of the Urbana PUD showing changes in the area over time. a.) predevelopment conditions in April 1988 (Source: USGS), b.) initial stages of development in March 2000 (source: Frederick County), c.) conditions in March-April 2005 (source: Frederick County), and d.) conditions in June 2007 (Source: National Agricultural Imagery Program, NAIP).

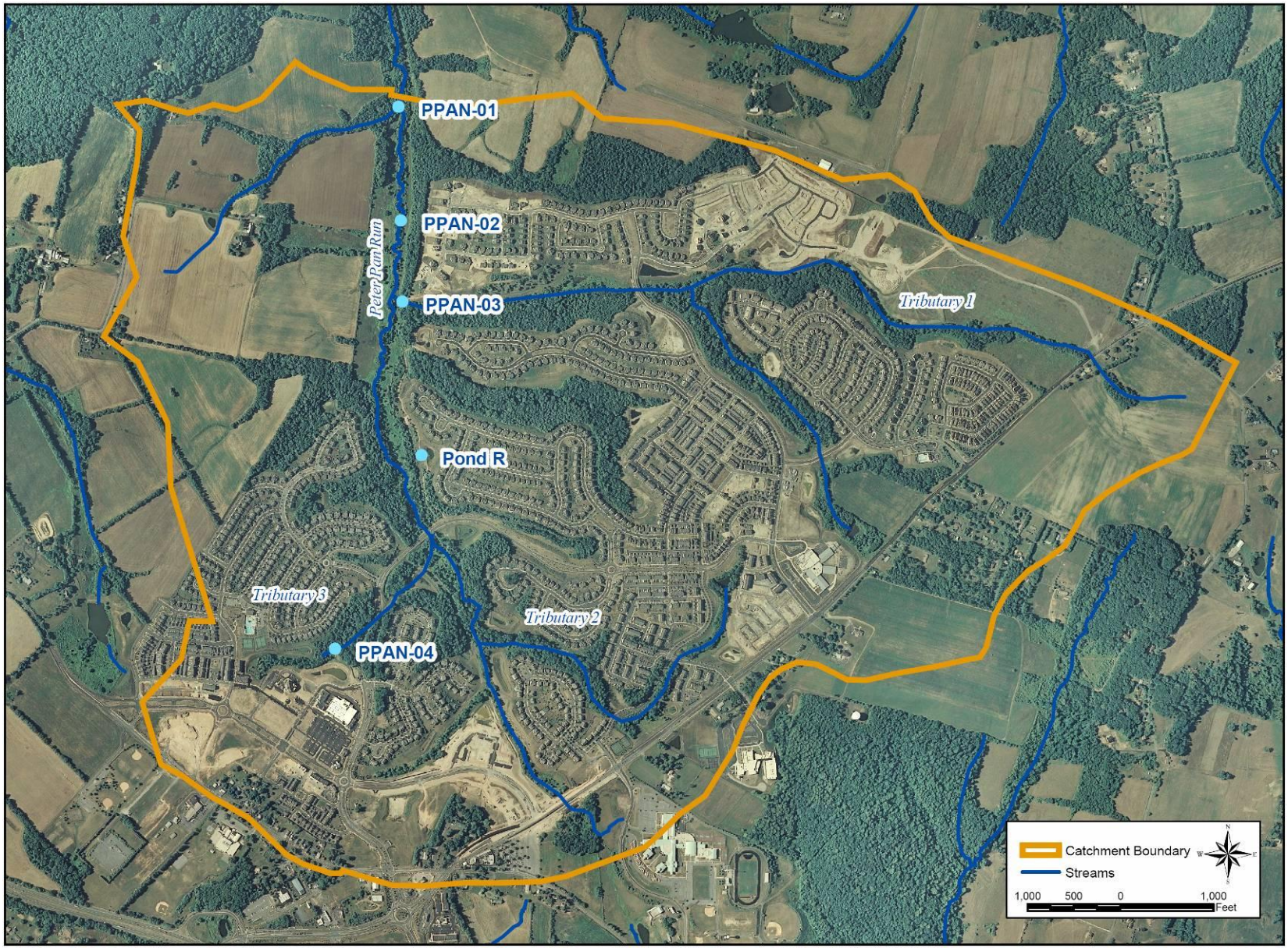

Figure 5-2. Annotated aerial photograph (June 2007) of Peter Pan Run in Lower Bush Creek watershed, Frederick County, Maryland showing the Peter Pan Run monitoring stations. (Source: NAIP)

and no non-structural BMPs have been completed within the Peter Pan Run catchment area. A number of other facilities currently function as sediment basins or are under construction within the Peter Pan Run catchment. These data will be updated in future years as SWM construction and other management programs progress.

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. 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* (Jones and Roth 2005), and *Quality Assurance Project Plan for Biological and Physical Monitoring in Peter Pan Run and Other Selected Watersheds* (Morgan and Roth 2005).

Currently, and as approved by MDE, methodology to assess streams in Frederick County is comparable to those used by other counties in Maryland, which facilitates integration of Frederick County's monitoring efforts with those of state and 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. 2007) 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 data 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 in Tables 5-1 and 5-2.

Table 5-1. Annual physical and biological sampling schedule for watershed monitoring stations

Spring (March through April)	**Summer** (June to 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, air and water temperature	Ambient water quality: • dissolved oxygen, specific conductivity, pH, turbidity, air and water temperature
Biological monitoring: • benthic macroinvertebrates	Biological monitoring: • fish

Table 5-2. Annual stream chemistry sampling schedule for the instream and outfall stations	
Baseflow (Monthly)	**Wet Weather** (up to 3 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

The County has also used these methods to assess ecological stream conditions elsewhere in Frederick County. Specifically, the County began assessing watersheds in order of decreasing priority as part of its Permit. The County initiated watershed monitoring in the Lower Bush Creek watershed in 1999, and resurveyed conditions again in 2001 and 2006. The County's second priority watershed, Ballenger Creek, was assessed in 2000 and 2002/2003. Lower Linganore Creek, the County's third priority watershed, was assessed initially in 2001 and again in 2005. Bennett and Catoctin Creeks were assessed in 2007 as part of a pilot program for the Frederick County Stream Survey (FCSS), a countywide stream monitoring program. Starting in 2008, every watershed in the county is being evaluated as part of the FCSS, as described in Section 5.1.5. Additional stream monitoring to support watershed restoration efforts continued in 2009 as described in Section 7.

5.1.1 Chemical Monitoring

As specified in the 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 outfall draining a specific land use (Pond R) and an associated in-stream station (site PPAN-01; Figure 5-2).

Peter Pan Instream Site

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 and related site features are presented in Figure 5-3.

Land use immediately surrounding the Peter Pan instream site remains primarily agricultural; however, recent construction within the Urbana PUD has occurred within approximately 500 yards of the station. The instream site is located on the west bank of Peter Pan Run. The site 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 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 sewer line extends eastward, along the north side of Tributary 1.

Figure 5-3a. The “storm box” and rain gauge at the ambient instream monitoring station at Peter Pan Run in the Lower Bush Creek Watershed, Frederick County, MD. The storm box contains an ISCO sampler, streamflow meter, battery, and a data recording unit. Photograph taken in January 2010.

Figure 5-3b. 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 in 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 in January 2010.

Outfall Site

Within the Urbana PUD, the outfall at Pond R (Figure 5-4) is monitored as a land use-specific stormwater management structure. Installation of water chemistry monitoring and automated sampling equipment was completed on December 24, 2002. Initial monitoring characterized water quality at the outfall of the basin during residential construction. Conversion of the Pond R sediment trap began in approximately late March 2004 and concluded during the first week of July 2004. Monitoring at this site continues as specified in the Permit.

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.

Figure 5-4. Villages of Urbana "Pond R" outfall water chemistry monitoring station. Photograph taken January 2010.

5.1.1.1 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 in Water Year (WY) 2009 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 has occurred only when flow is present since its conversion to a stormwater BMP in July 2004; this condition is infrequent.

Monthly storm sampling of Peter Pan Run and Pond R was performed using ISCO automated samplers and flowmeters located at each water chemistry monitoring station. Storm event monitoring at the ambient station (PPAN-01) and the outfall station (POND-R) began in May 1999 and February 2003, respectively. For each storm, the equipment at each station was used to 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, TPH, phenols, and fecal coliform) using dedicated bottles containing preservative. An electronic rain gauge located at the outfall station recorded data to determine storm event validity (i.e., rainfall quantity greater than 0.10"). At each station, the flowmeter measured stage height and converted the value to a discharge rate. Flow rate at the instream station was determined automatically by comparing stage heights to rating curve data collected during the year. Discharge measurements were collected using the USGS' stream velocity profile measurement technique (USGS 1982), and updated, as needed. The flow rate of water exiting the outfall pipe at the Pond R monitoring station was calculated using Manning's Equation. 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 5-3. Samples were stored on ice or in dedicated sample refrigerators until they could be transported under chain of custody to the laboratory. Sample analysis was conducted by Martel Laboratories, Inc., of Towson, MD. Field and laboratory results from the monitored storms are discussed in the sections below.

5.1.1.2 Storm Information

Between October 1, 2008 and September 30, 2009, 11 storms were monitored at the Peter Pan Run instream station and at the Pond R outfall station. Baseflow monitoring was carried out at a targeted once-monthly rate for the entire year at the instream site. During this year, baseflow monitoring was not conducted at the Pond R outfall stations due to lack of discharge during baseflow conditions. As presented in Table 5-4, storm rainfall ranged in quantity from 0.15 to 1.64 inches, and in duration from 3.25 hours to 25.5 hours. Average rainfall intensities monitored ranged from 0.02 to 0.23 inches/hour.

Hydrographs and hyetographs showing flow rate and rainfall, respectively, over the course of each storm are presented in Figures 5-5a through 5-5k for the instream station and in Figures 5-6a through 5-6k for the outfall station. Note that for Figures 5-6e through 5-6h, flow rate hydrographs may appear erratic due to small scale changes in flow rate at the outfall.

Table 5-5 compares monthly rainfall totals recorded at the Peter Pan Run stations to monthly data collected at two local NOAA weather monitoring stations (NOAA 2010). The NOAA weather stations at Catoctin Mountain Park, MD and Clarksburg, MD are approximately 15 miles north-northwest and 6 miles south-southeast, respectively, of the Urbana PUD. Rainfall amounts recorded at the Pond R outfall station during monitored storms are presented in Figure 5-7.

Table 5-3. Parameters and detection limits for Frederick County's Water Chemistry Monitoring Program

Parameter	Detection Limit	Method
Biochemical Oxygen Demand (5-day)	1 mg/l	SM 5210 B
Total Kjeldahl Nitrogen (TKN)	0.5 mg/l	SM4500NH3-C
Total Phosphorus	0.01 mg/l	SM 4500P-E
Total Suspended Solids (TSS)	1 mg/l	SM 2540 D
Zinc	10 Φg/l	EPA 200.8
Cadmium	0.5 Φg/l	EPA 200.8
Copper	2 Φg/l	EPA 200.8
Lead	2 Φg/l	EPA 200.8
Phenols	0.01 mg/l	EPA 420.2
Total Petroleum Hydrocarbons (TPH)	5 mg/l	EPA 1664
Fecal Coliform	2/100 ml	SM 9221E
Oil and Grease	5 mg/l	EPA 1664
Nitrate and Nitrite	0.04 mg/l	SM 4500NO3-H

Table 5-4. Summary of storm events monitored in WY 2009 at the Peter Pan Run station

Date	Start Time	Rainfall Duration (hrs)	Rainfall (in)	Avg. Intensity (in/hr)	Storm as % of Total Rainfall for Month
10/25/2008	10:00	7.25	1.64	0.23	93%
11/14/2008	8:45	6.25	0.76	0.12	28%
12/12/2008	7:00	9	0.27	0.03	7%
1/6/2009	21:30	17.5	0.86	0.05	67%
2/19/2009	12:00	3.25	0.15	0.05	42%
3/27/2009	12:15	15.25	0.3	0.02	17%
4/4/2009	23:45	11	0.58	0.05	16%
5/30/2009	14:30	9.5	0.89	0.09	17%
6/19/2009	10:00	25.5	1.32	0.05	25%
7/23/2009	16:15	6.25	1.29	0.21	33%
9/12/2009	13:00	5.75	0.31	0.05	17%

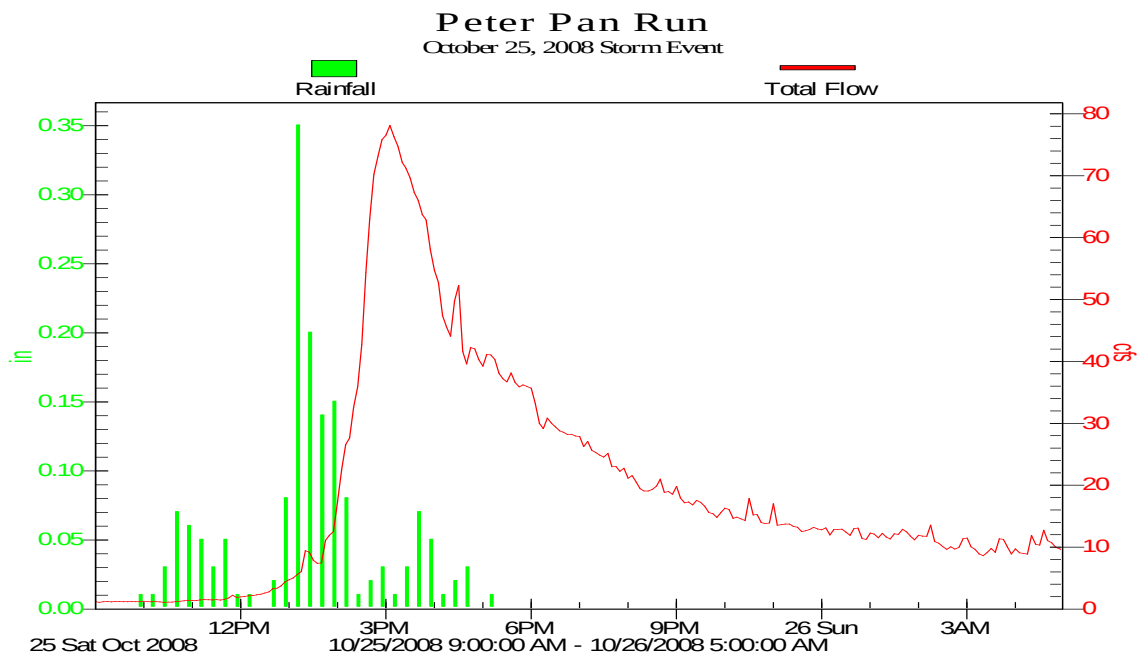

Figure 5-5a. Hydrograph and rainfall (recorded at 15 min. intervals) for the October 25, 2008 storm event at the Peter Pan Run instream station. Storm event total rainfall was 1.64 inches.

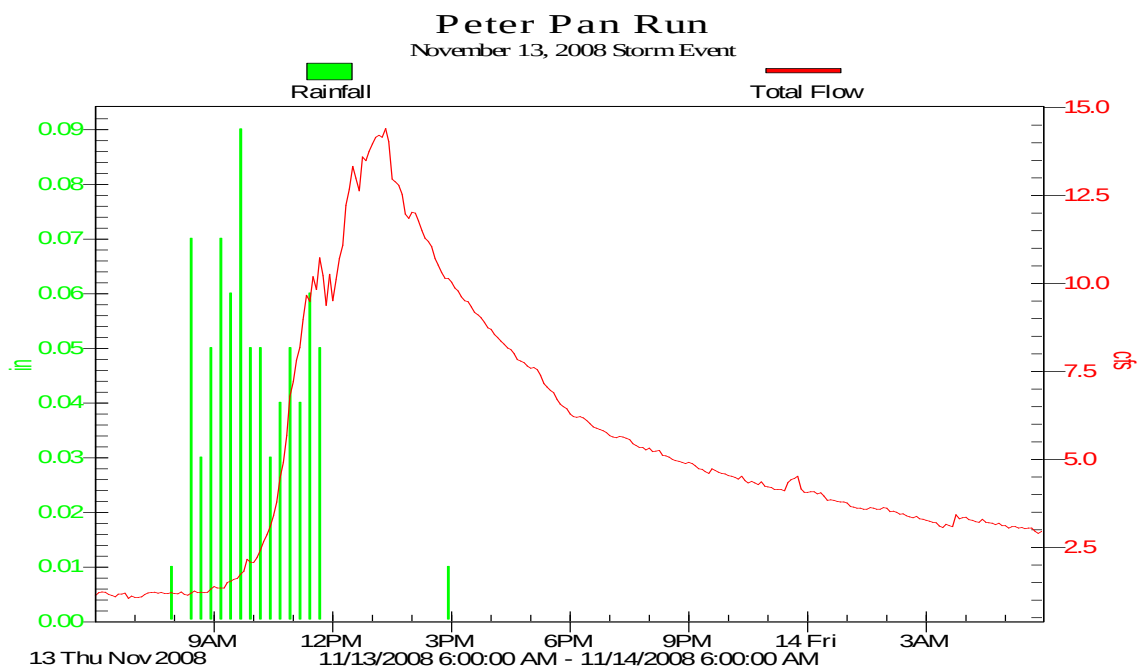

Figure 5-5b. Hydrograph and rainfall (recorded at 15 min. intervals) for the November 13, 2008 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.76 inches

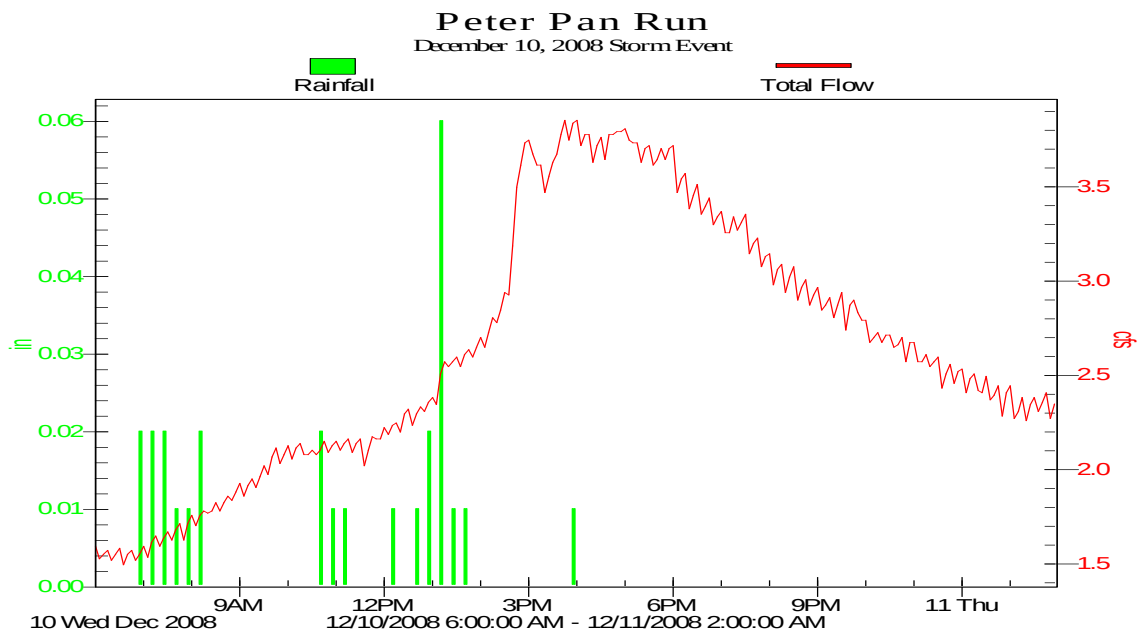

Figure 5-5c. Hydrograph and rainfall (recorded at 15 min. intervals) for the December 10, 2008 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.27 inches.

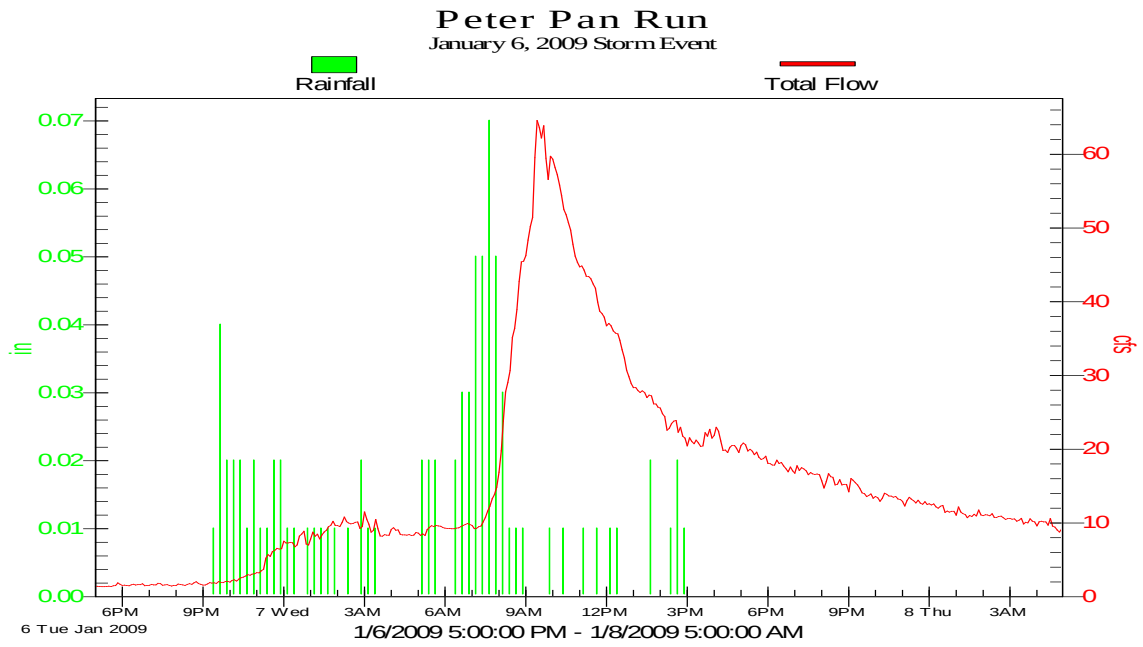

Figure 5-5d. Hydrograph and rainfall (recorded at 15 min. intervals) for the January 6, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.86 inches.

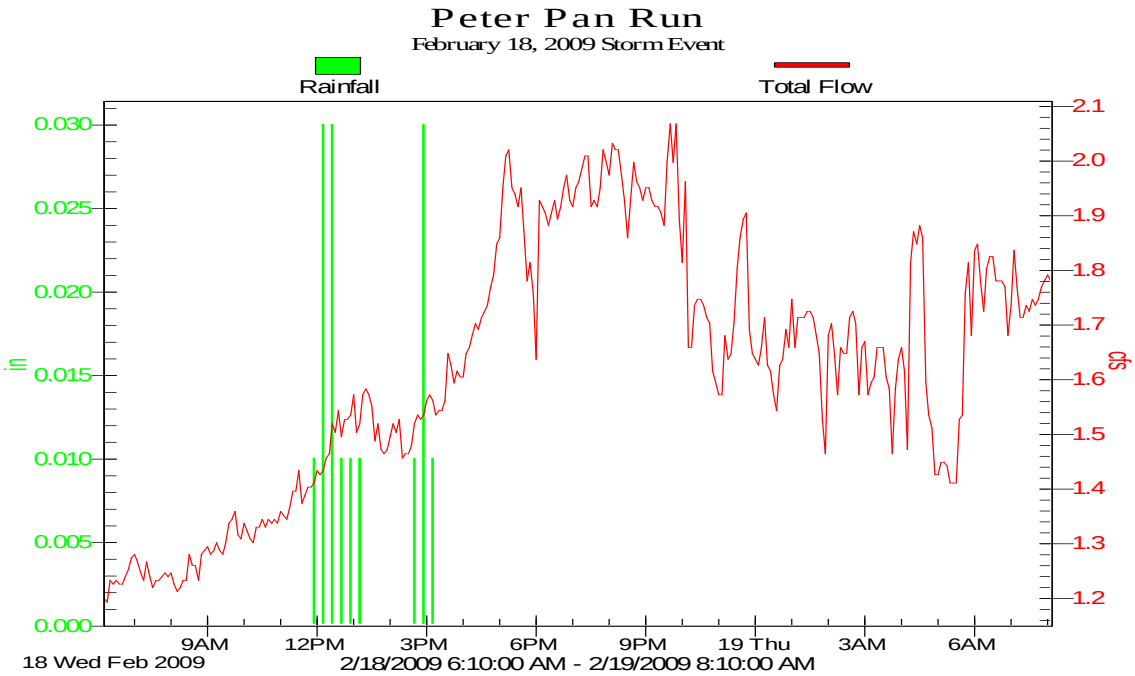

Figure 5-5e. Hydrograph and rainfall (recorded at 15 min. intervals) for the February 18, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.15 inches.

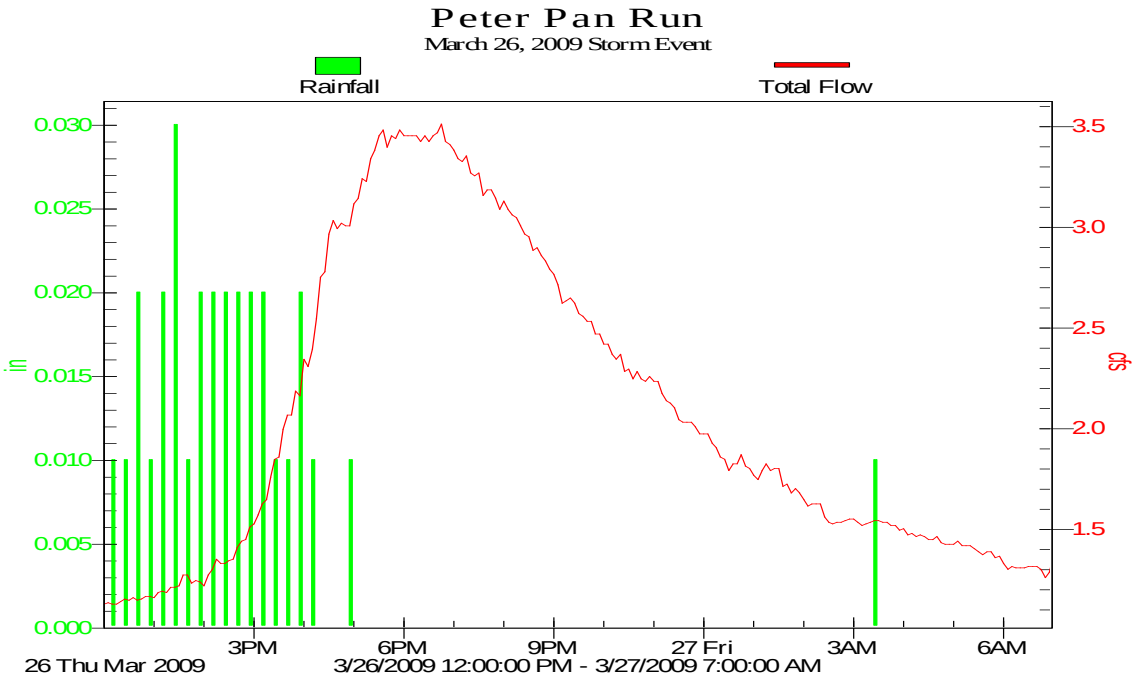

Figure 5-5f. Hydrograph and rainfall (recorded at 15 min. intervals) for the March 26, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.30 inches.

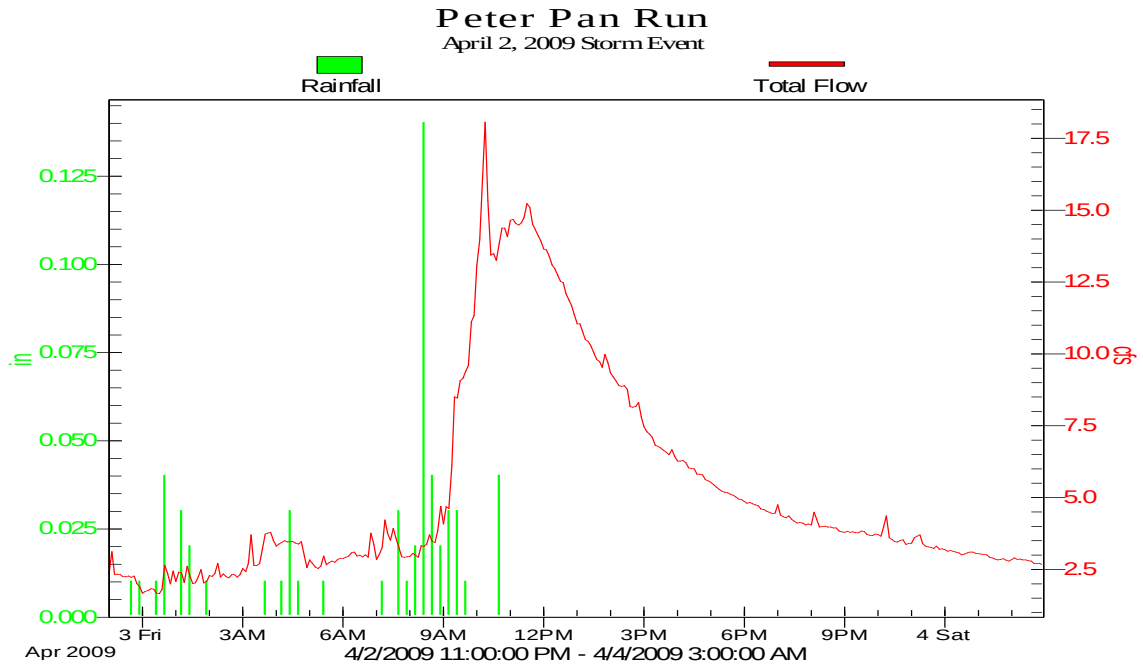

Figure 5-5g. Hydrograph and rainfall (recorded at 15 min. intervals) for the April 2, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.58 inches.

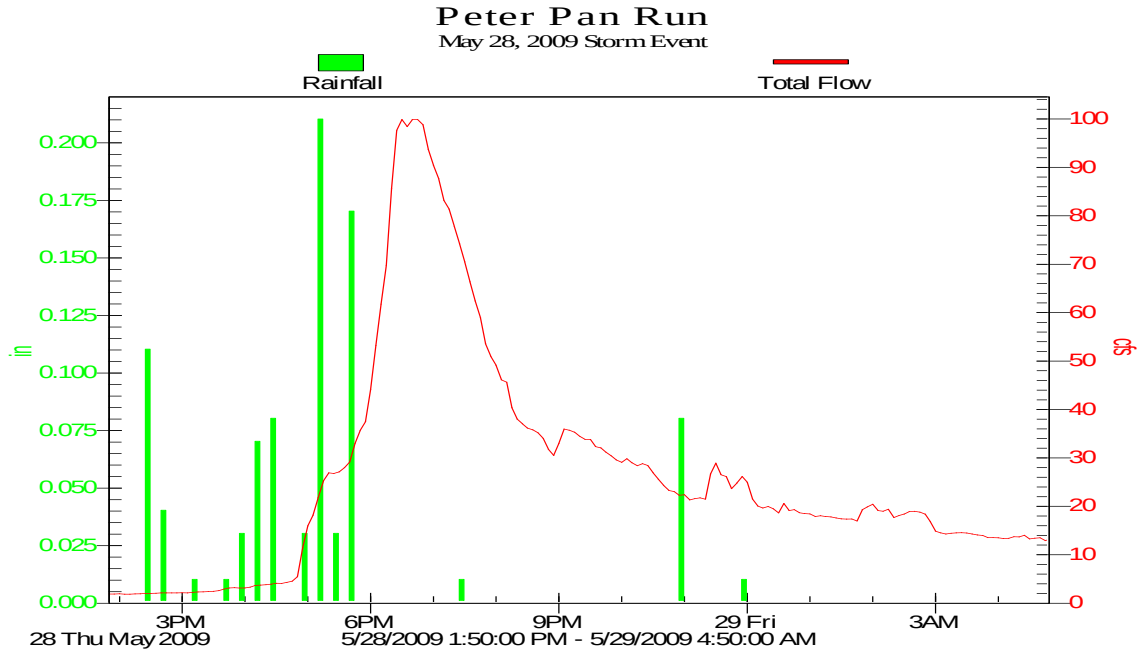

Figure 5-5h. Hydrograph and rainfall (recorded at 15 min. intervals) for the May 28, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.89 inches.

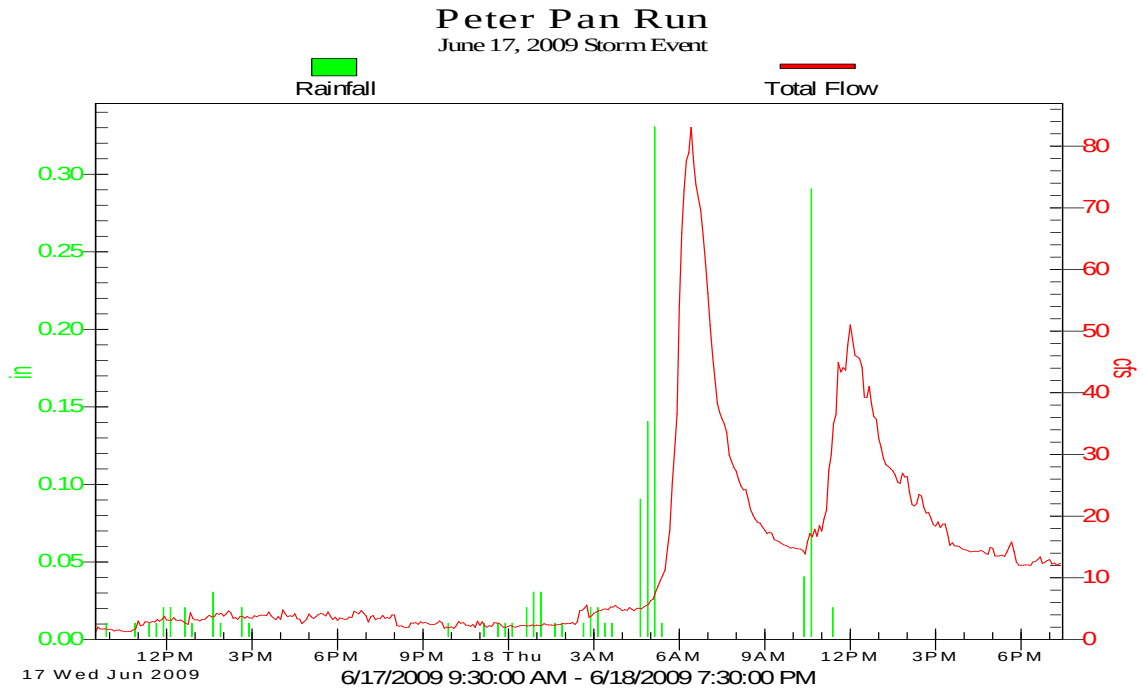

Figure 5-5i. Hydrograph and rainfall (recorded at 15 min. intervals) for the June 17, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 1.32 inches.

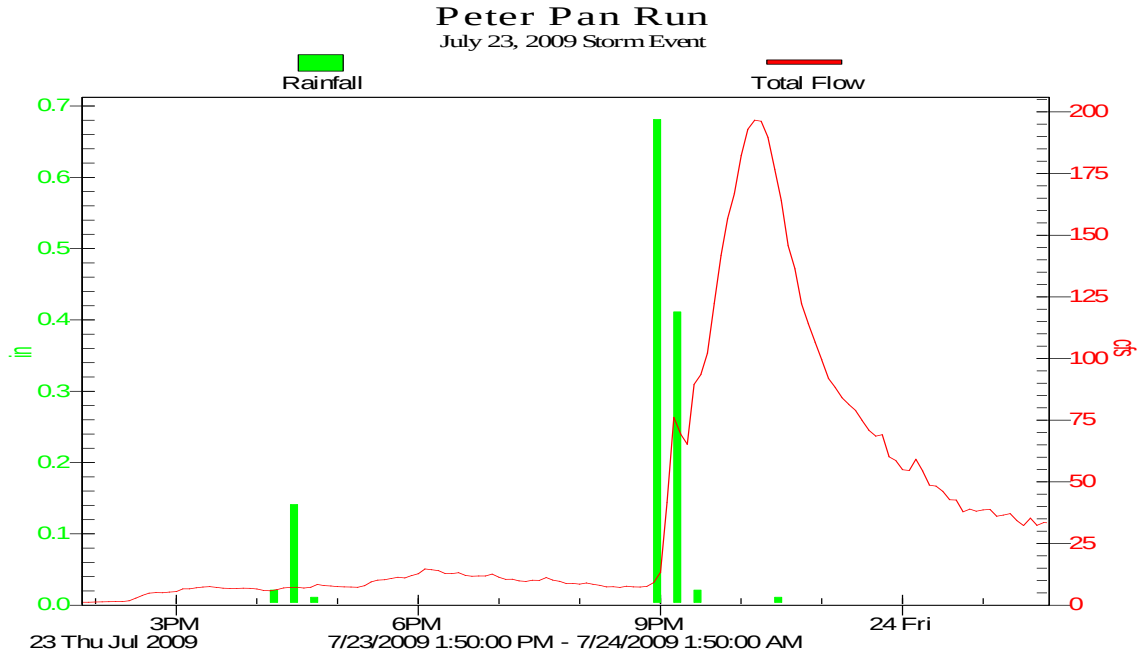

Figure 5-5j. Hydrograph and rainfall (recorded at 15 min. intervals) for the July 23, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 1.29 inches.

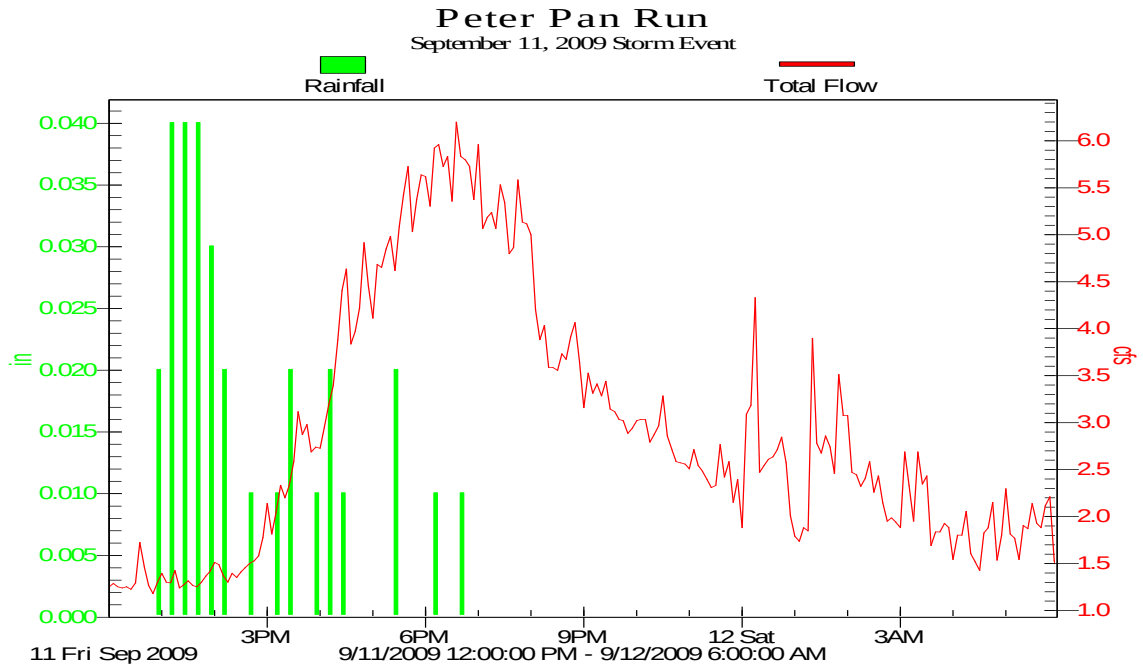

Figure 5-5k. Hydrograph and rainfall (recorded at 15 min. intervals) for the September 11, 2009 storm event at the Peter Pan Run instream station. Storm event total rainfall was 0.31 inches.

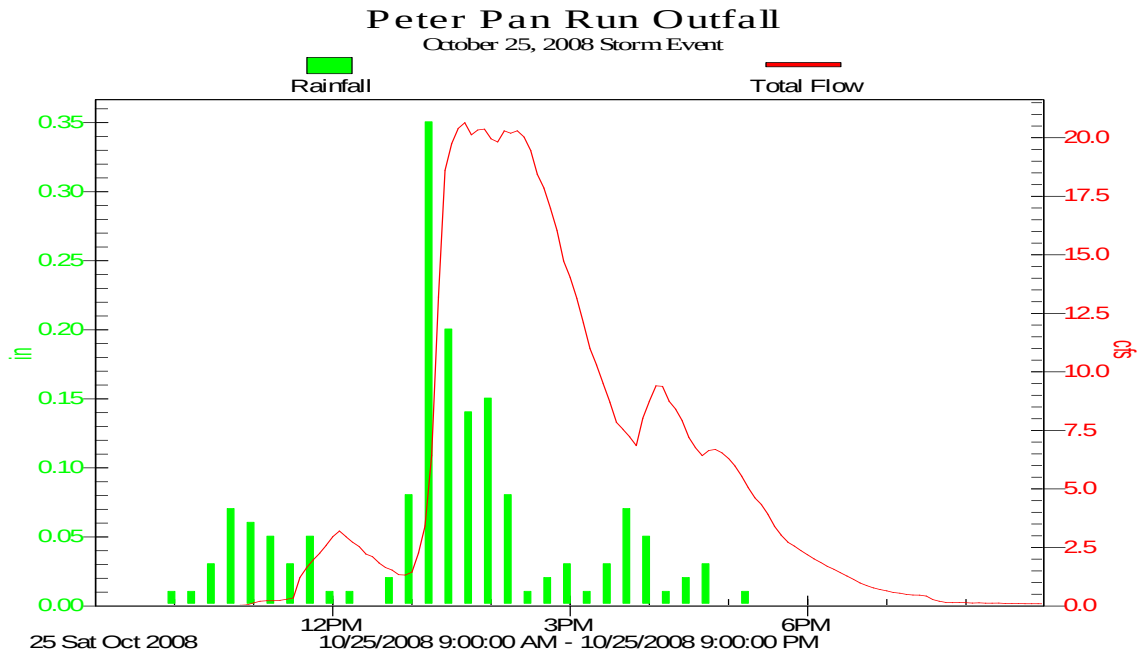

Figure 5-6a. Hydrograph and rainfall (recorded at 15 min. intervals) for the October 25, 2008 storm event at the Pond R outfall station. Storm event total rainfall was 1.64 inches.

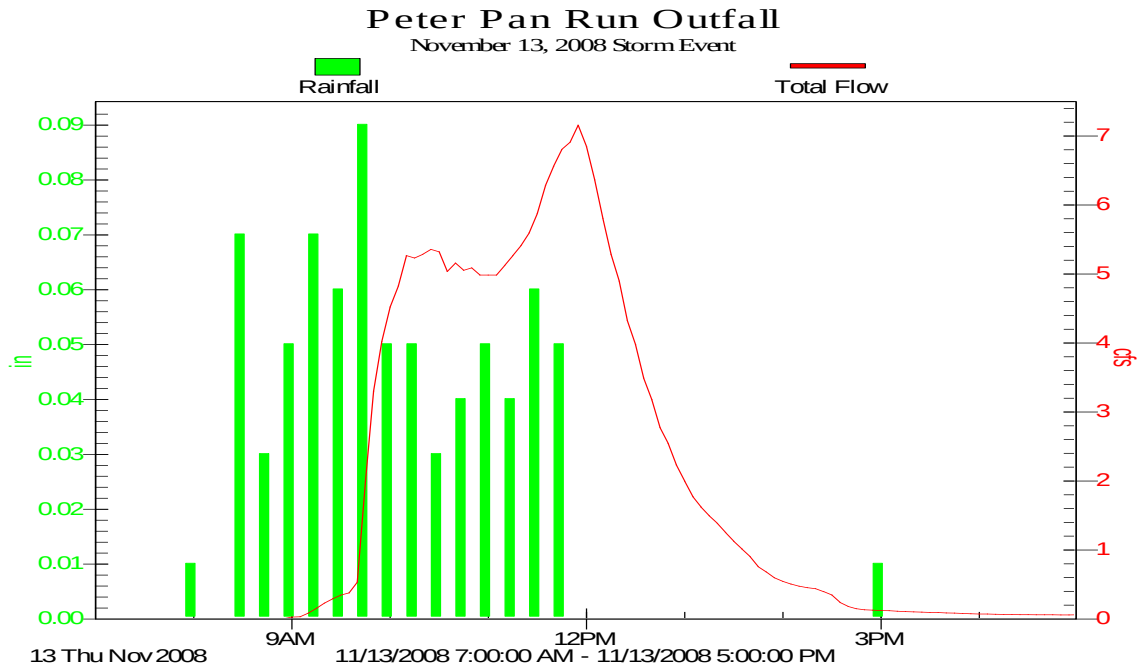

Figure 5-6b. Hydrograph and rainfall (recorded at 15 min. intervals) for the November 15, 2008 storm event at the Pond R outfall station. Storm event total rainfall was 0.76 inches.

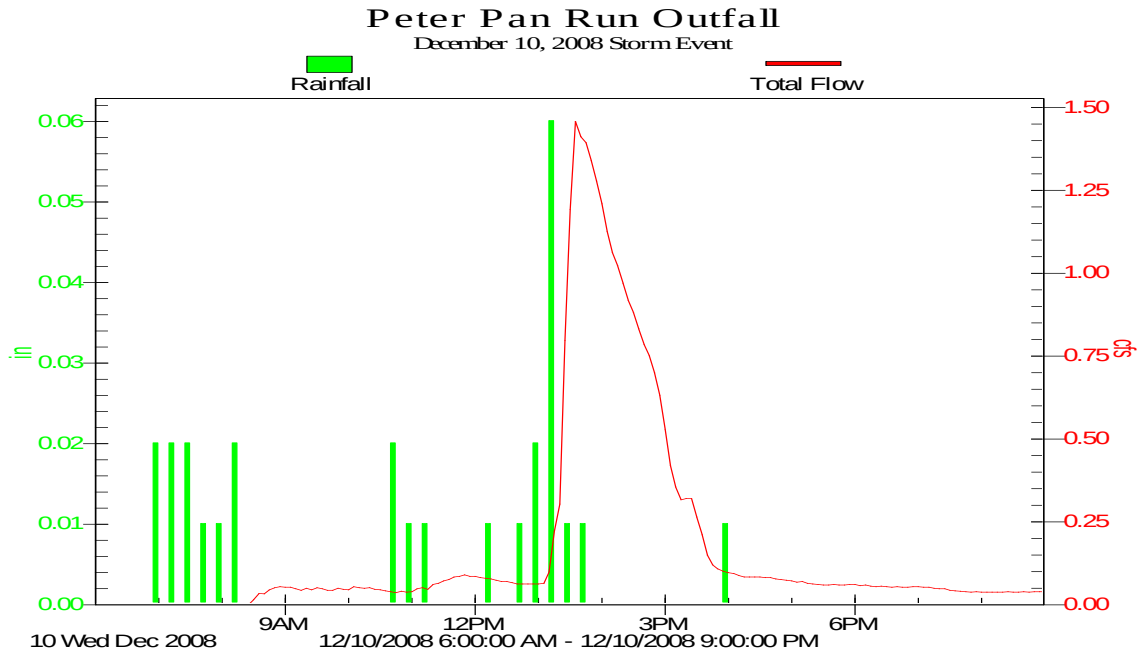

Figure 5-6c. Hydrograph and rainfall (recorded at 15 min. intervals) for the December 10, 2008 storm event at the Pond R outfall station. Storm event total rainfall was 0.27 inches.

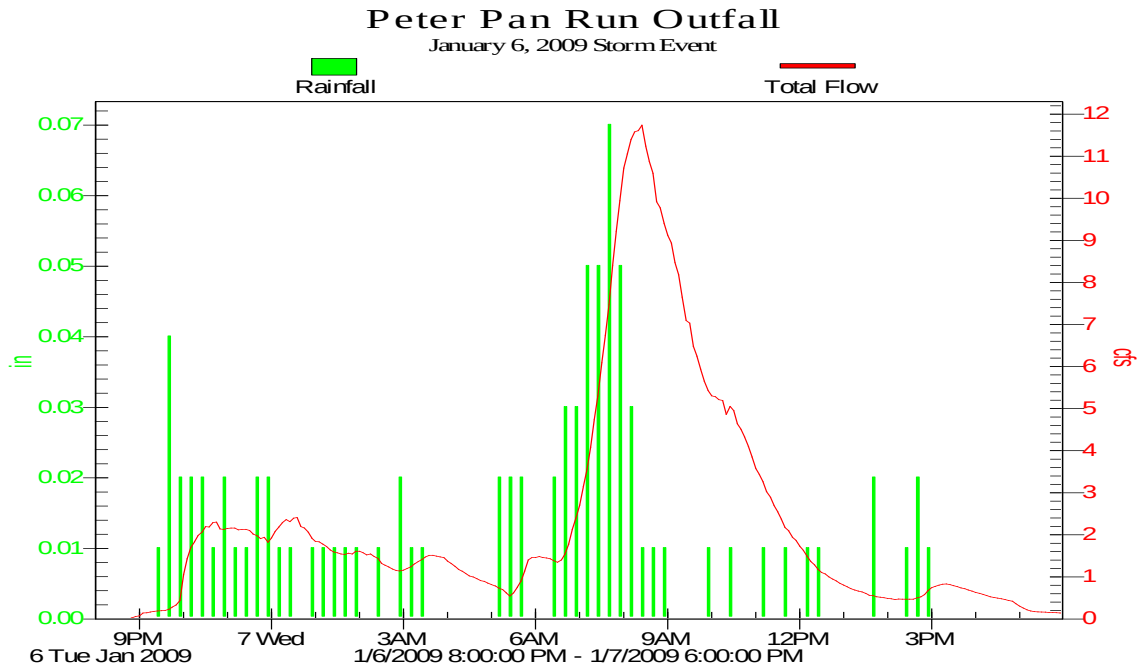

Figure 5-6d. Hydrograph and rainfall (recorded at 15 min. intervals) for the January 6, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.86 inches.

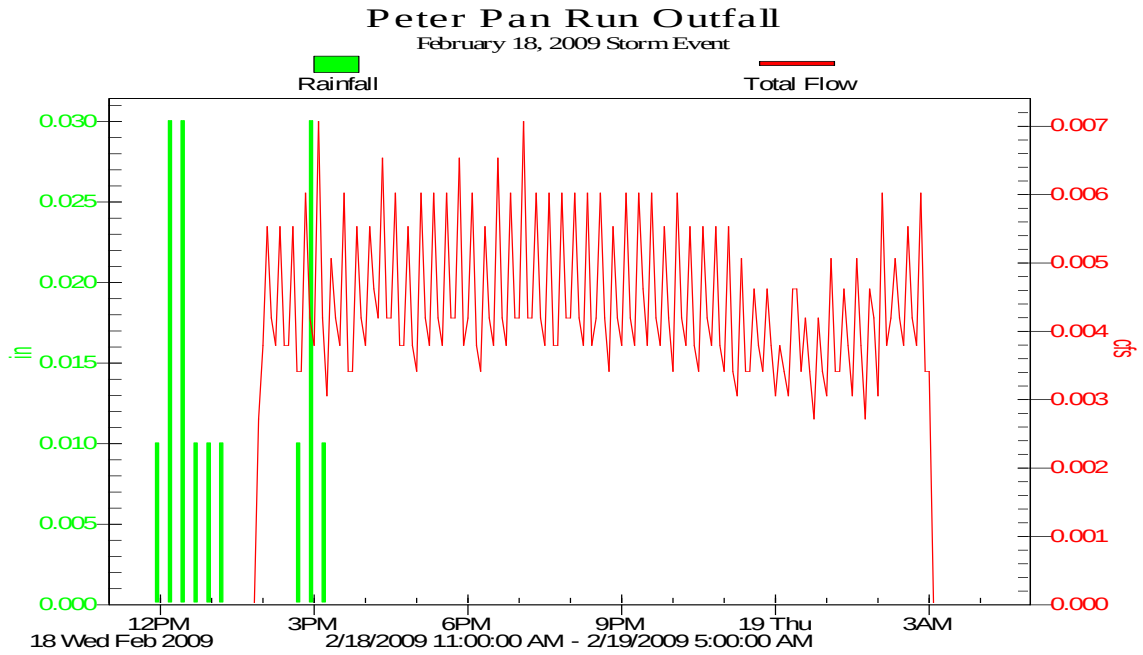

Figure 5-6e. Hydrograph and rainfall (recorded at 15 min. intervals) for the February 18, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.15 inches.

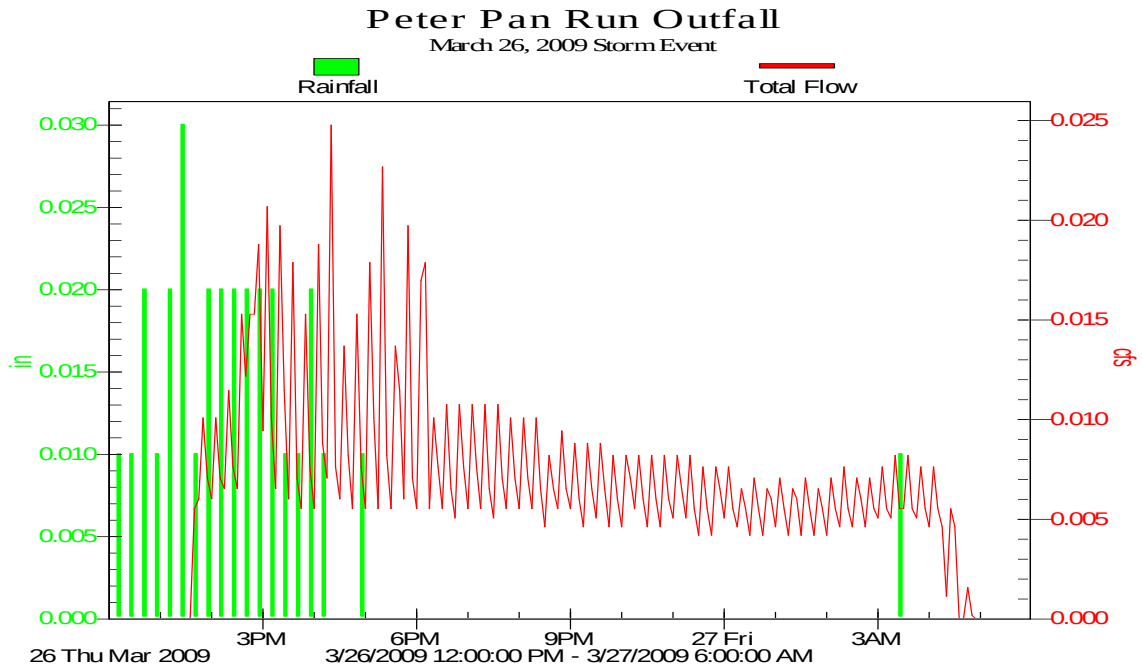

Figure 5-6f. Hydrograph and rainfall (recorded at 15 min. intervals) for the March 26, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.30 inches.

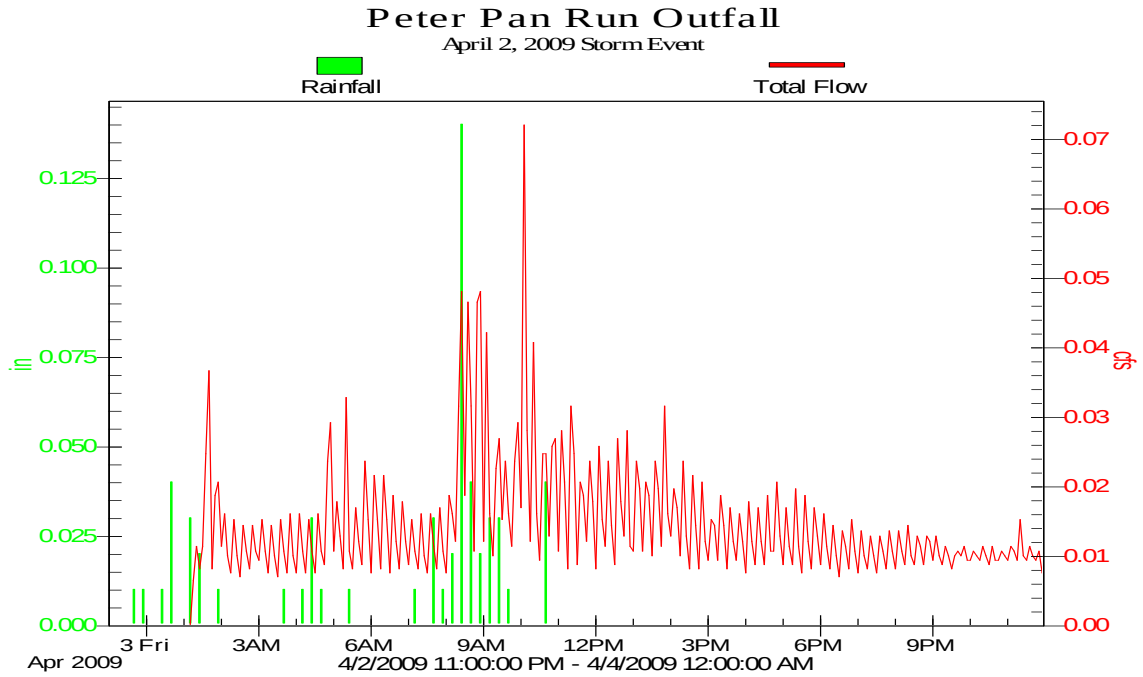

Figure 5-6g. Hydrograph and rainfall (recorded at 15 min. intervals) for the April 2, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.58 inches.

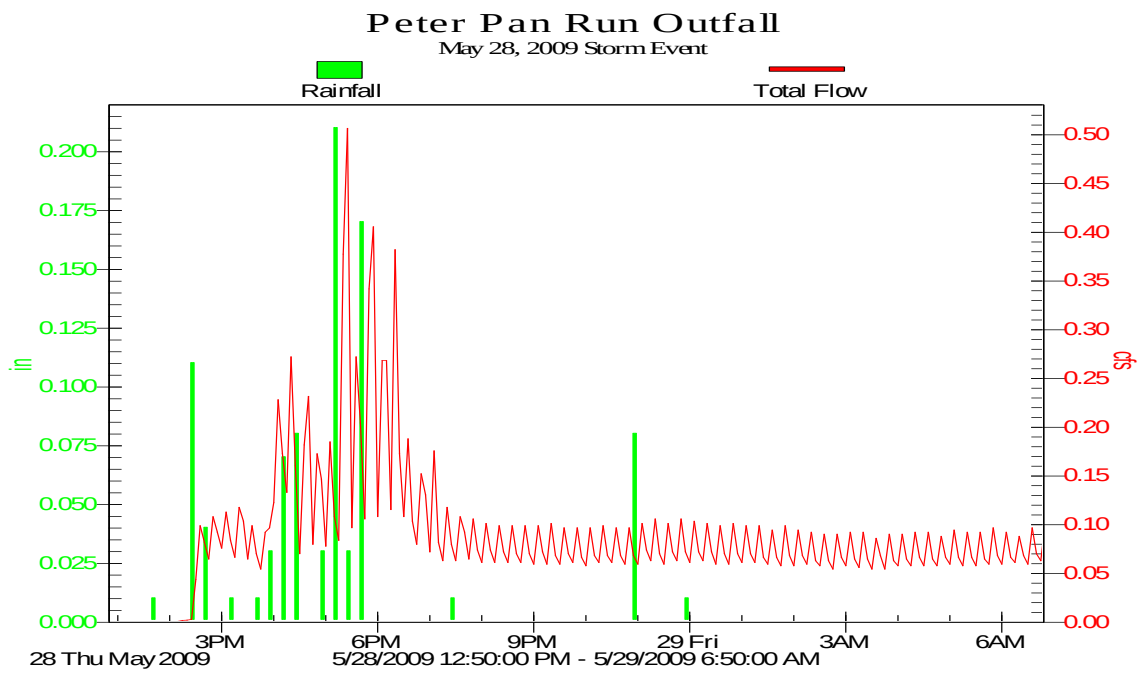

Figure 5-6h. Hydrograph and rainfall (recorded at 15 min. intervals) for the May 28, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.89 inches.

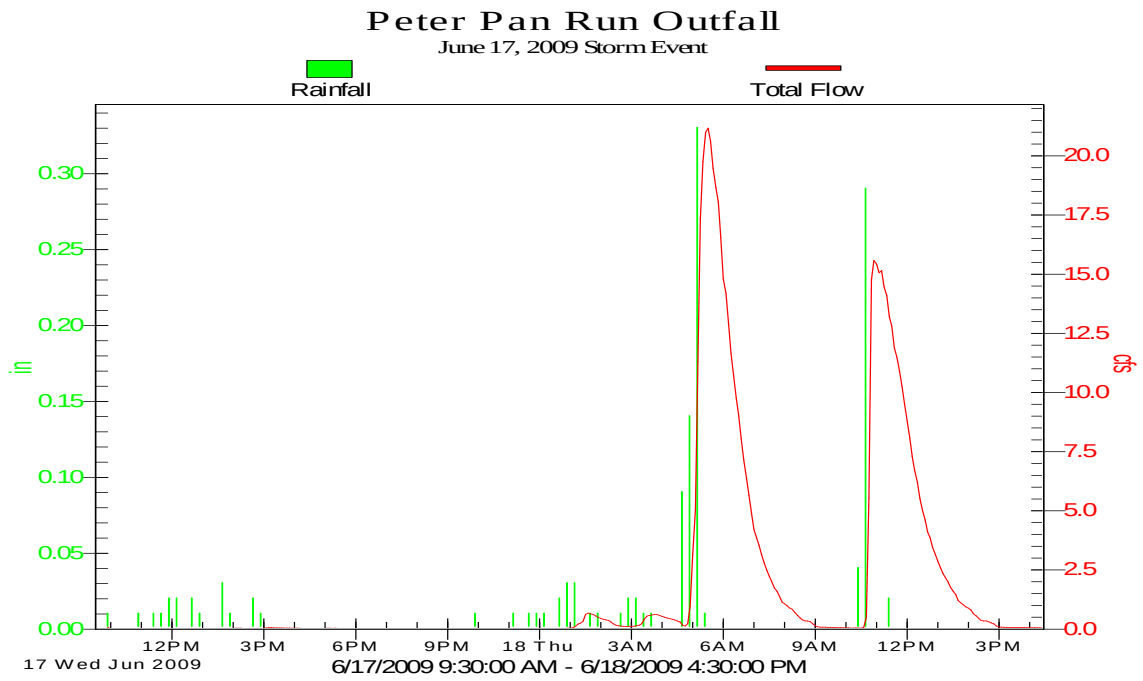

Figure 5-6i. Hydrograph and rainfall (recorded at 15 min. intervals) for the June 17, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 1.32 inches.

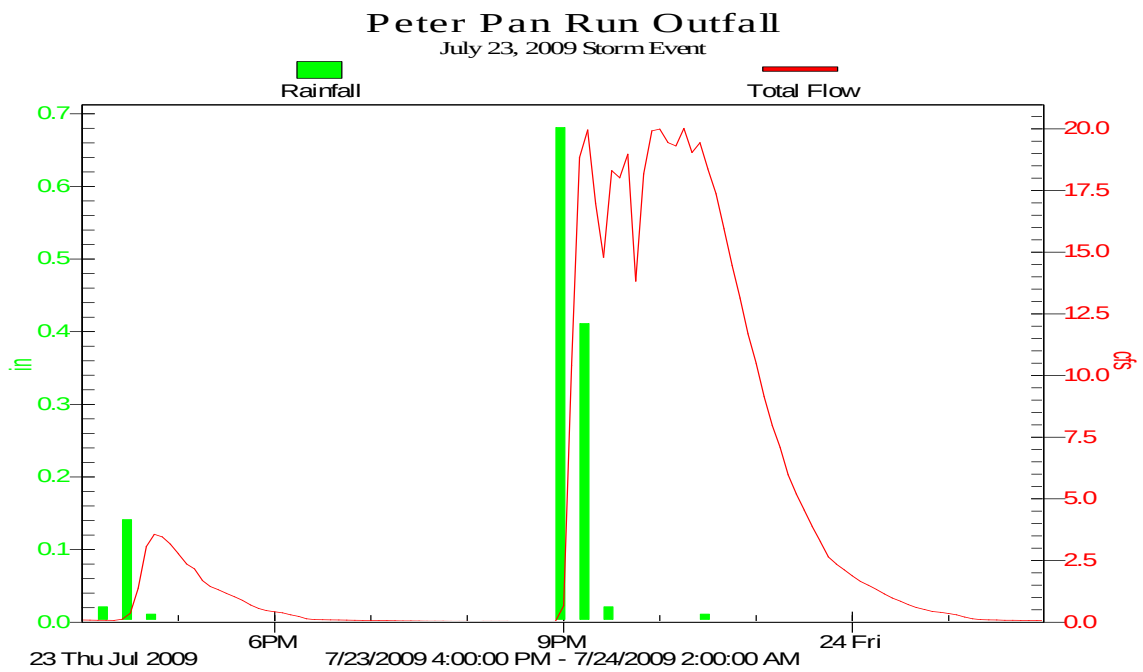

Figure 5-6j. Hydrograph and rainfall (recorded at 15 min. intervals) for the July 23, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 1.29 inches.

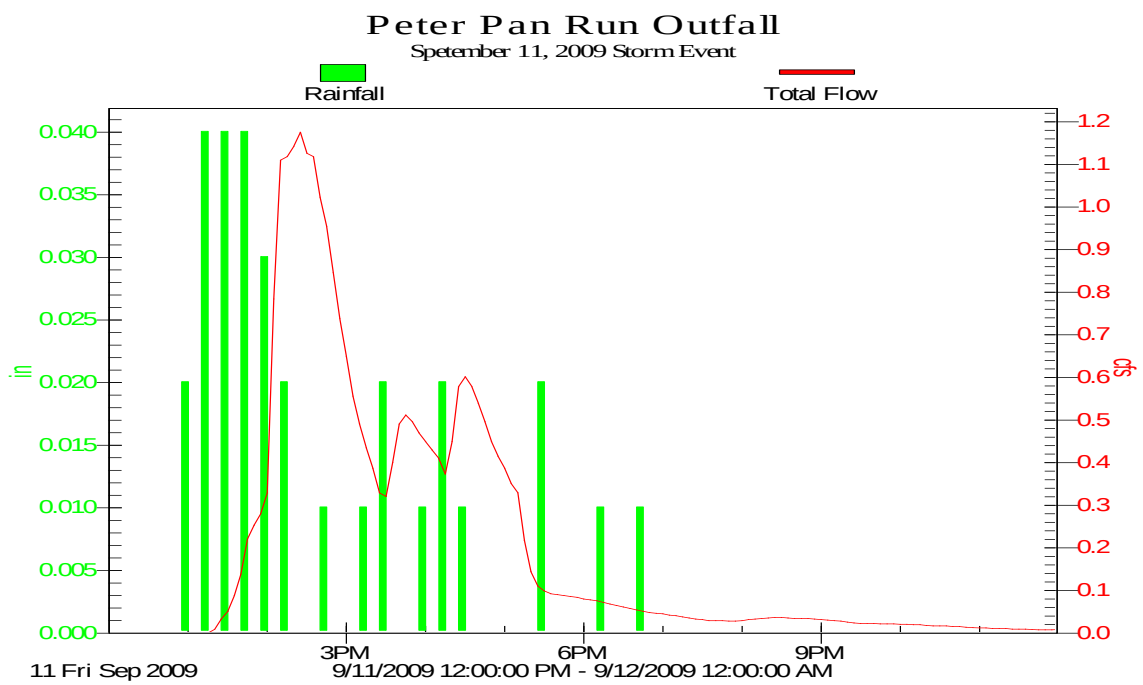

Figure 5-6k. Hydrograph and rainfall (recorded at 15 min. intervals) for the September 11, 2009 storm event at the Pond R outfall station. Storm event total rainfall was 0.31 inches.

Table 5-5. Rainfall data (totals by month; inches)					
Month	**Versar[a]**	**Clarksburg[b]**	**Catoctin Mountain Park[b]**	**Normal[c]**	**Departure from Normal[c]**
October-08	1.76	1.49	3.84	3.1	-1.3
November-08	2.69	N.R.	3.05	3.3	-0.6
December-08	3.8	N.R.	4.26	2.9	0.9
January-09	1.29	2.55	0.94	2.8	-1.5
February-09	0.36	0.48	4.59	2.7	-2.3
March-09	1.76	3.18	3.86	3.3	-1.5
April-09	3.67	4.27	6.53	3.3	0.4
May-09	5.19	8.06	6.48	4.3	0.9
June-09	5.26	5.75	3.01	3.9	1.4
July-09	3.89	5.19	2.87	3.7	0.2
August-09	1.86	5.47	3.07	3.5	-0.2
September-09	1.76	N.R.	6.38	3.6	-1.7

[a] Versar rainfall data from ISCO gauge at Peter Pan Run outfall site.
[b] Clarksburg and Catoctin Mountain Park rainfall data from National Oceanic and Atmospheric Administration.
[c] Based on Frederick County regional long-term rainfall data from National Oceanic and Atmospheric Administration.
N.R. = not reported

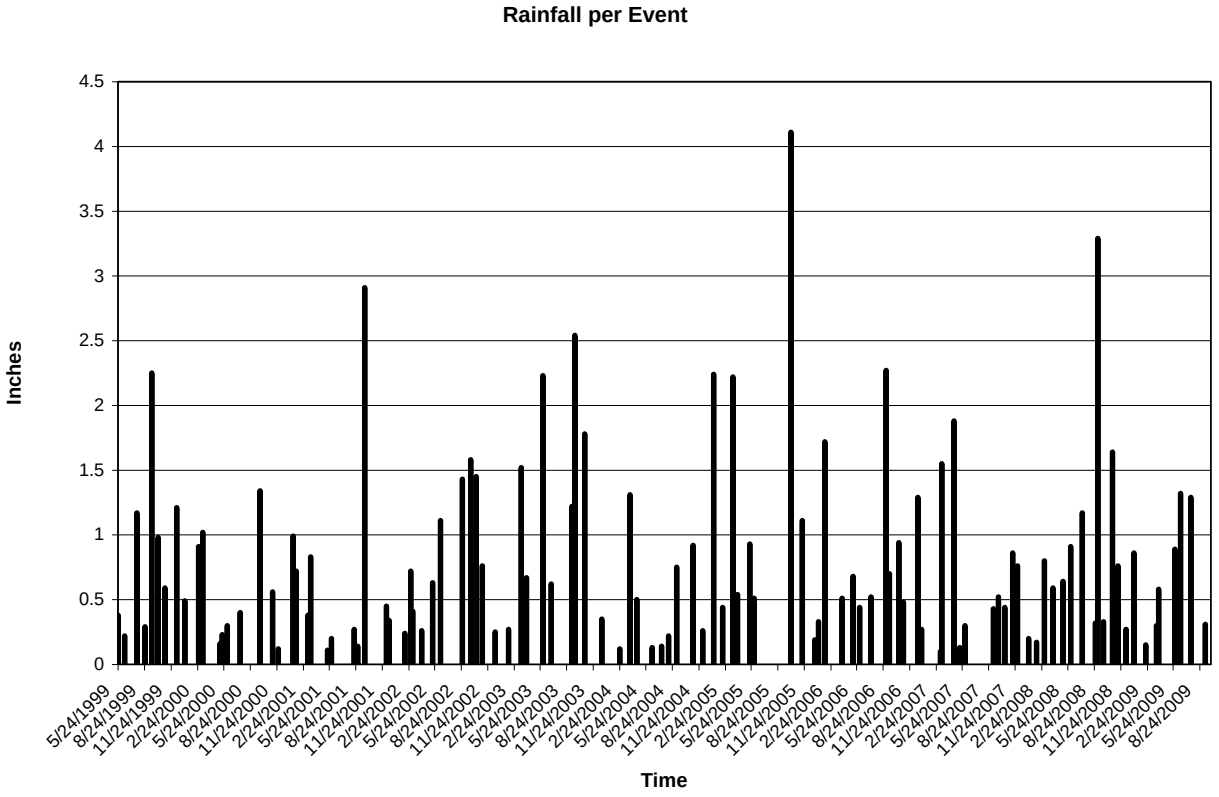

Figure 5-7. Rainfall totals for sampled storm events, Peter Pan Run instream monitoring station (May 1999 to September 2009)

For WY 2009, annual rainfall near the sites as recorded at NOAA's Catoctin Mountain Park gauge (48.88 inches) was characterized as above normal. The NOAA gauge at Clarksburg (the only nearby site currently operating which has complete, though limited, historical data) recorded 36.44 inches (Figure 5-8) compared to the long-term annual average of 40.4 inches recorded in Frederick County. Note that November 2008, December 2008, and September 2009 rainfall is missing from the Clarksburg site. Versar's rain gauge, located at Pond R, reported 34.84 inches for the year. The Versar gauge recorded higher than normal rainfalls, compared to Frederick County averages, for five months during the year (Figure 5-9). The consequent annual discharge volume at the Peter Pan Run monitoring station was 0.2% greater than the prior year (Figure 5-10).

Because construction of the PUD has altered land use and increased impervious surfaces within the watershed, there may be changes over time in the volume of storm discharges, peak height, and time of onset of storm flow peak. The discharge volume per inch of rainfall (for monitored storms) shows no trend (Figure 5-11). The slopes of the regression lines, however, were the least steep during the driest years (WY 2001 and WY 2002), suggesting greater infiltration during those years. The discharge volume per inch of rainfall in WY 2009 was significantly different than the drought WY 2002 only.

5.1.1.3 Water Chemistry Analysis

Laboratory Results

A summary of analytical results for baseflow and storm event water chemistry monitoring at the Peter Pan instream site and Pond R outfall site from October 2008 through September 2009 is shown in Tables 5-6a through 5-6d. This information has been entered into Frederick County's long-term database for storm and baseflow data and is included as hard copy in Appendix C and electronically as part of this report submission. The data presented in Appendix C contain additional data not presented in Tables 5-6a through 5-6d.

Field teams collected first flush grab samples (oil and grease, phenols, TPH, and fecal coliform) during four of the complete storms monitored at the instream station and three storms at the Pond R outfall. First flush samples were not able to be taken during any other monitored events. Most often, events began or were projected to begin between midnight and 6 a.m. One event initiated at 7 a.m.; however, for that event, conditions were not safe to carry out first-flush sampling because of morning snow mixed with rain, and the ISCO autosampler had been pre-programmed the previous evening. During one other event field crew could not wait for Pond R outfall to discharge in order for the instream fecal coliform sample to be delivered to the laboratory and be analyzed within its hold time.

Calculation of Event Mean Concentration

Storm event mean concentrations (EMC) of the various pollutants were calculated from laboratory results from 11 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. Table 5-7 presents the annual, calculated average EMCs, Maryland freshwater acute and chronic water

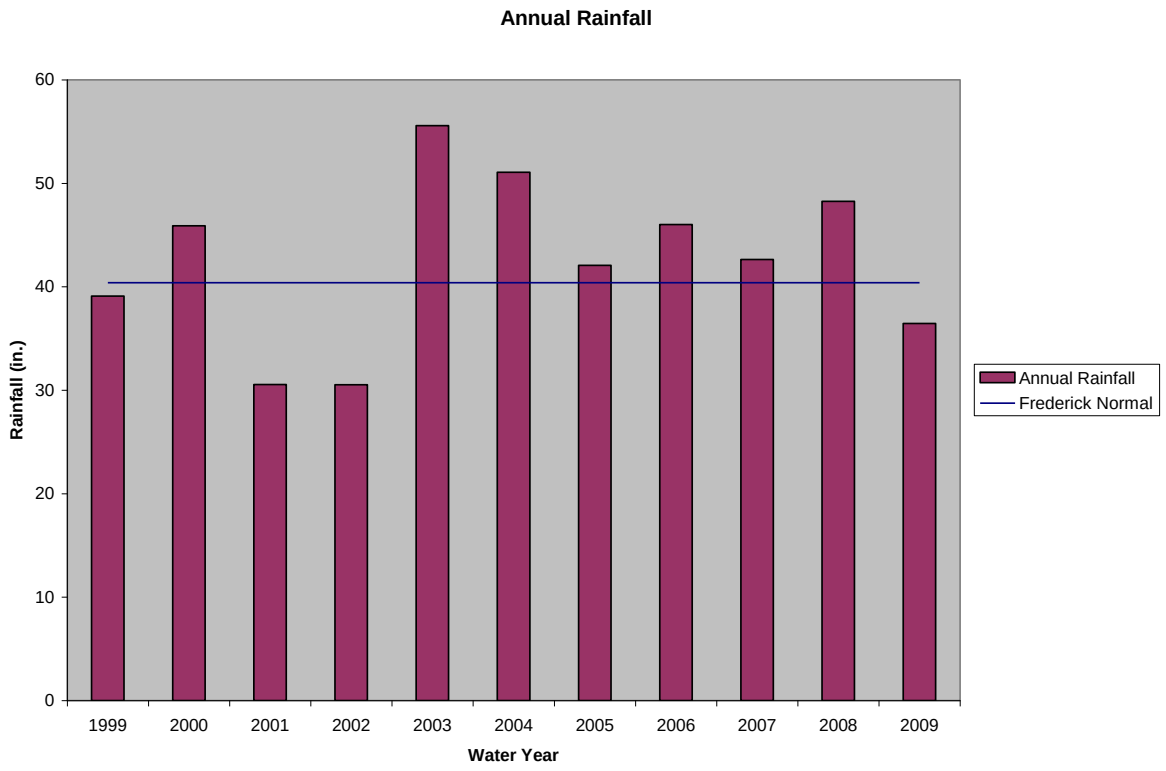

Figure 5-8. Annual rainfall recorded at NOAA's Emmitsburg, MD station, WY 1999-2004 and at NOAA's Clarksburg, MD station, WY 2005-2009. Note: Clarksburg data for WY 2006 do not include November 2005; Clarksburg data for WY 2009 do not include November 2008, December 2008, and September 2009.

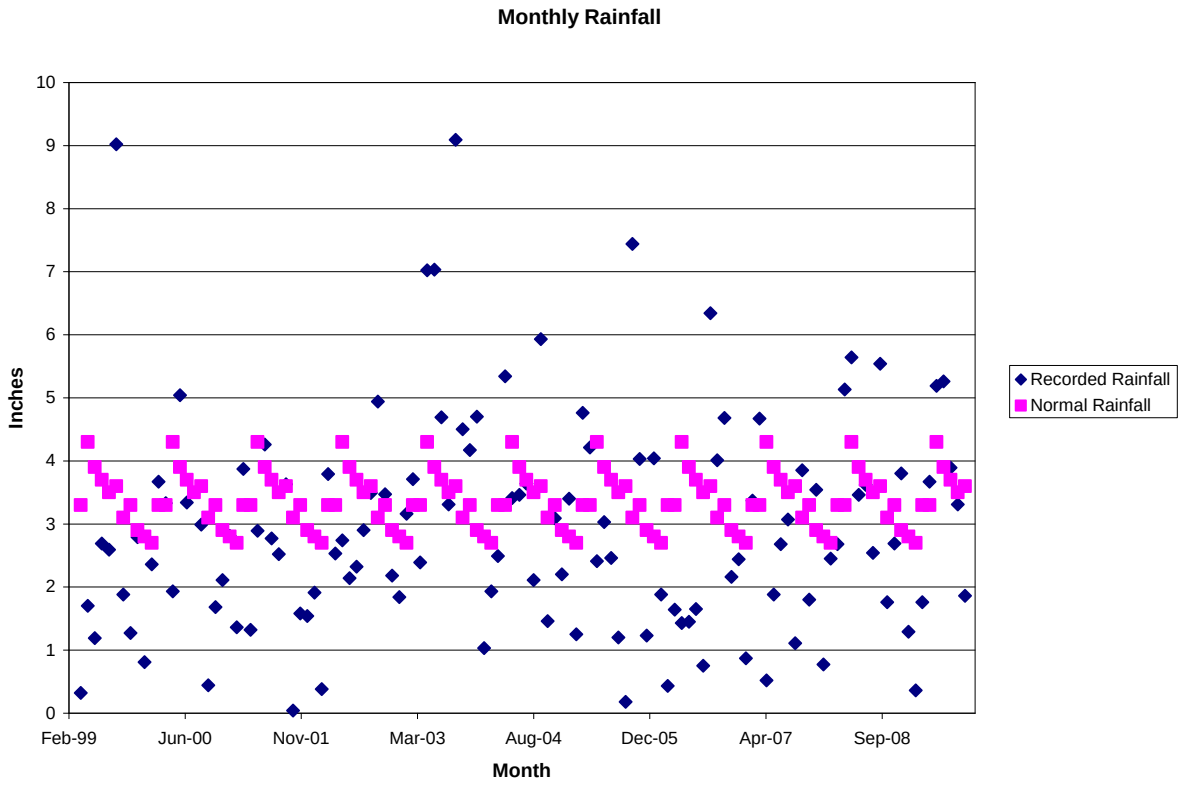

Figure 5-9. Monthly rainfall recorded at the Peter Pan site and long-term average monthly (i.e., normal) rainfall for NOAA's Frederick County, MD station.

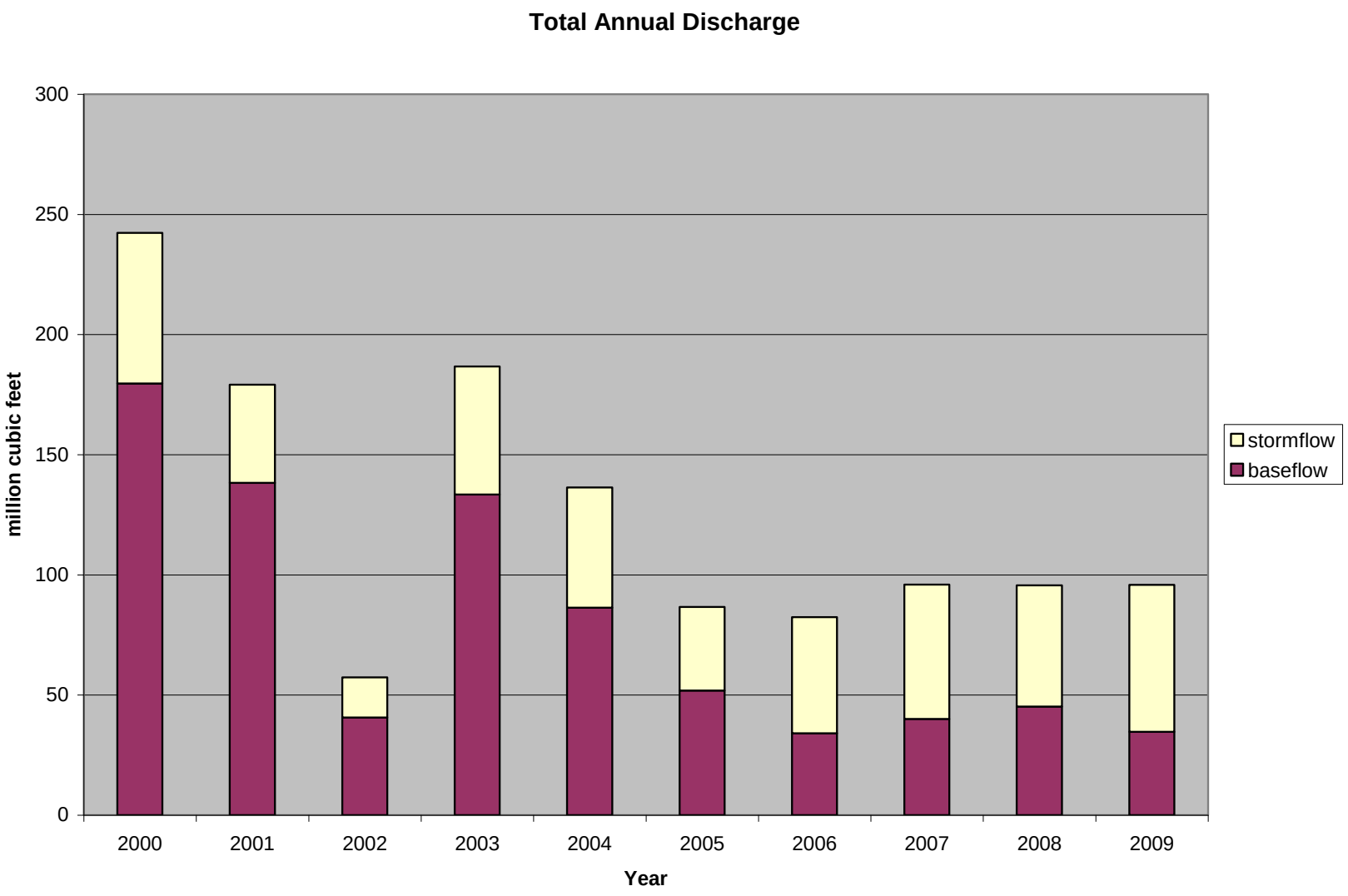

Figure 5-10. Annual discharge volume measured at Peter Pan Run instream monitoring station, WY 2000-2009

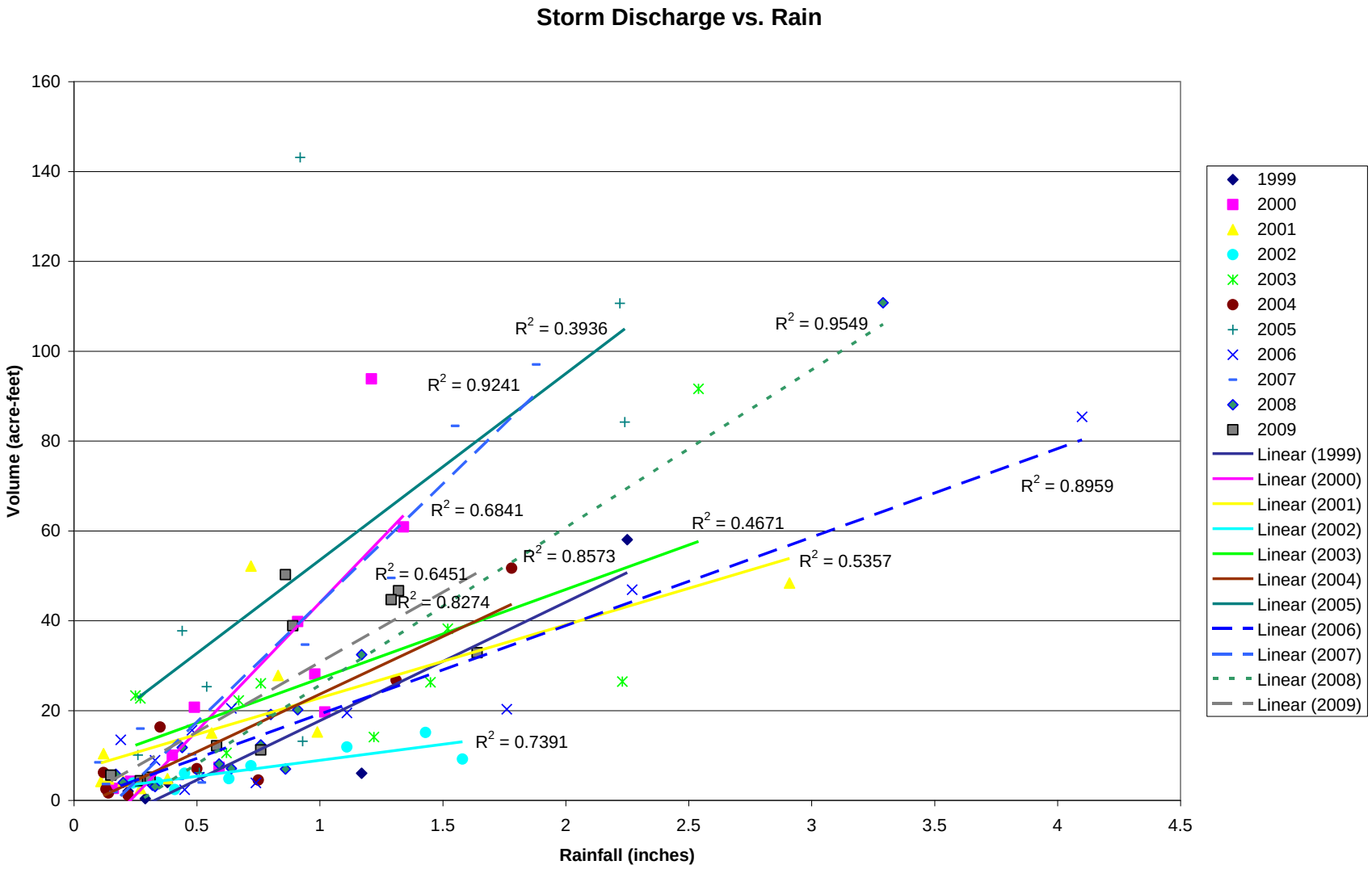

Figure 5-11. Storm discharge plotted as a function of rainfall for storm events monitored at Peter Pan Run, for each year sampled, WY 1999-2009

Table 5-6a. Water chemistry results for instream stormwater monitoring at Peter Pan Run (mg/l). Fecal coliform results are in MPN/100 mL. Highlighted values indicate that results may exceed MD freshwater acute criteria.*

ID	DATE	STAT	BOD	TKN	Phosph	TSS	Cadmium*	Copper*	Lead*	Zinc*	Colif*	TPH	Phenols	Oil+Grease	Nitrate+Nitrite
	10/26/2008	Rising	2	<0.5	0.11	3	<0.0005	<0.002	<0.002	0.012	N/A	N/A	N/A	N/A	1.2
	10/26/2008	Peak	23	7.7	4.7	1500	<0.0005	0.034	0.031	0.16	N/A	N/A	N/A	N/A	0.94
	10/26/2008	Falling	3	<0.5	0.17	35	<0.0005	<0.002	<0.002	0.014	N/A	N/A	N/A	N/A	0.87
	11/14/2008	Rising	<5	<0.5	0.31	23	<0.0005	0.0041	0.0052	0.024	N/A	N/A	N/A	N/A	1.5
	11/14/2008	Peak	4	<0.5	0.17	25	<0.0005	0.0082	0.012	0.041	N/A	N/A	N/A	N/A	1.1
	11/14/2008	Falling	4	<0.5	0.10	10	<0.0005	<0.002	<0.002	0.011	N/A	N/A	N/A	N/A	1.1
	12/12/2008	Rising	<5	<0.5	0.10	2	<0.0005	<0.002	<0.002	0.013	N/A	N/A	N/A	N/A	2.6
	12/12/2008	Peak	<5	<0.5	0.05	1	<0.0005	<0.002	<0.002	0.013	N/A	N/A	N/A	N/A	2.2
	12/12/2008	Falling	<5	<0.5	0.05	2	<0.0005	<0.002	<0.002	<0.01	N/A	N/A	N/A	N/A	2.1
	1/8/2009	Rising	<1	1.7	0.25	10	0.00084	0.0023	<0.002	0.018	23	5.8	<0.01	<5	2.3
	1/8/2009	Peak	4	4.0	1.9	160	0.0011	0.011	0.0094	0.054	N/A	N/A	N/A	N/A	1.1
	1/8/2009	Falling	2	1.2	0.39	140	0.0016	0.0048	0.0052	0.029	N/A	N/A	N/A	N/A	1.3
	2/18/2009	Rising	3	1.3	0.04	51	<0.0005	<0.002	<0.002	<0.01	N/A	N/A	N/A	N/A	2.6
	2/18/2009	Peak	<1	1.0	0.02	1	<0.0006	0.0024	<0.002	0.01	N/A	N/A	N/A	N/A	2.6
	2/18/2009	Falling	<1	0.7	0.22	2	<0.0007	<0.002	<0.002	<0.01	N/A	N/A	N/A	N/A	2.6
	3/27/2009	Rising	<5	1.0	0.04	3	0.0014	<0.002	<0.002	0.017	N/A	N/A	N/A	N/A	2.2
	3/27/2009	Peak	<5	1.0	0.10	21	<0.0005	0.011	<0.002	0.015	N/A	N/A	N/A	N/A	2.0
	3/27/2009	Falling	<5	1.0	0.05	16	0.00058	<0.002	<0.002	0.012	N/A	N/A	N/A	N/A	1.9
	4/4/2009	Rising	<5	1.3	0.06	270	<0.0005	<0.002	<0.002	0.016	N/A	N/A	N/A	N/A	0.83
	4/4/2009	Peak	<5	2.4	0.14	9	<0.0005	0.0068	<0.002	0.026	N/A	N/A	N/A	N/A	<0.02
	4/4/2009	Falling	<5	1.3	0.09	6	<0.0005	<0.002	<0.002	0.015	N/A	N/A	N/A	N/A	1.0
	5/30/2009	Rising	8	1.6	0.34	36	<0.0005	0.0042	0.0035	0.042	1200	<5	<0.01	<5	1.6
	5/30/2009	Peak	<5	2.4	0.25	38	<0.0005	0.015	0.011	0.068	N/A	N/A	N/A	N/A	1.3
	5/30/2009	Falling	3	1.3	0.16	7	<0.0005	0.0029	<0.002	0.015	N/A	N/A	N/A	N/A	1.3
	6/19/2009	Rising	<1	0.7	0.02	<1	<0.0005	<0.002	<0.002	0.027	930	<5	<0.01	7.3	2.8
	6/19/2009	Peak	3	1.3	0.30	58	0.00071	0.03	0.028	0.15	N/A	N/A	N/A	N/A	0.95
	6/19/2009	Falling	<1	0.7	0.09	<1	<0.0005	0.0024	<0.002	0.026	N/A	N/A	N/A	N/A	1.1
	7/24/2009	Rising	<5	1.6	0.14	61	<0.0005	0.004	0.005	0.017	930	<5	<0.01	<5	1.6
	7/24/2009	Peak	<5	0.7	0.24	290	<0.0005	<0.002	<0.002	0.017	N/A	N/A	N/A	N/A	1.3
	7/24/2009	Falling	<5	1.0	0.10	41	<0.0005	0.0028	<0.002	0.041	N/A	N/A	N/A	N/A	1.4
	9/12/2009	Rising	<5	0.6	0.03	1	<0.0005	<0.002	<0.002	<0.01	N/A	N/A	N/A	N/A	2.3
	9/12/2009	Peak	<5	1.1	0.03	61	<0.0005	<0.002	<0.002	<0.01	N/A	N/A	N/A	N/A	1.7
	9/12/2009	Falling	<5	1.0	0.11	5	0.0049	0.0022	<0.002	0.015	N/A	N/A	N/A	N/A	1.6

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

Table 5-6b. Water chemistry results for outfall stormwater monitoring at Pond R (mg/l). Fecal coliform results are in MPN/100 mL. Highlighted values indicate that results may exceed MD freshwater acute criteria.*

ID	DATE	STAT	BOD	TKN	Phosph	TSS	Cadmium*	Copper*	Lead*	Zinc*	Colif*	TPH	Phenols	Oil+Grease	Nitrate+Nitrite
	10/26/2008	Rising	4	0.6	0.38	10	<0.0005	0.0039	<0.002	0.038	N/A	N/A	N/A	N/A	0.38
	10/26/2008	Peak	3	<0.5	0.34	9	<0.0005	0.0024	<0.002	0.021	N/A	N/A	N/A	N/A	0.24
	10/26/2008	Falling	7	1.0	0.41	6	<0.0005	0.0038	<0.002	0.018	N/A	N/A	N/A	N/A	0.32
	11/14/2008	Rising	6	<0.5	0.21	4	<0.0005	0.0022	<0.002	0.027	N/A	N/A	N/A	N/A	0.62
	11/14/2008	Peak	5	<0.5	0.19	2	<0.0005	<0.002	<0.002	0.014	N/A	N/A	N/A	N/A	0.35
	11/14/2008	Falling	6	<0.5	0.31	6	<0.0005	0.0029	<0.002	0.021	N/A	N/A	N/A	N/A	0.50
	12/12/2008	Rising	<5	<0.5	0.18	6	<0.0005	0.0049	<0.002	0.025	N/A	N/A	N/A	N/A	0.61
	12/12/2008	Peak	<5	<0.5	0.11	4	<0.0005	0.00324	<0.002	0.0252	N/A	N/A	N/A	N/A	0.55
	12/12/2008	Falling	<5	<0.5	0.12	3	<0.0005	0.0031	<0.002	0.016	N/A	N/A	N/A	N/A	0.48
	1/8/2009	Rising	3	<0.5	0.12	6	0.0026	0.0047	<0.002	0.039	N/A	N/A	N/A	N/A	0.36
	1/8/2009	Peak	3	1.2	0.27	10	<0.0005	0.0031	<0.002	0.017	N/A	N/A	N/A	N/A	0.26
	1/8/2009	Falling	3	1.1	0.26	9	<0.0005	0.003	<0.002	0.016	N/A	N/A	N/A	N/A	0.28
	2/18/2009	Rising	10	1.2	0.06	16	<0.0005	0.01	0.002	0.053	N/A	N/A	N/A	N/A	0.87
	2/18/2009	Peak	8	2.4	0.31	8	<0.0005	0.0074	<0.002	0.038	N/A	N/A	N/A	N/A	0.78
	2/18/2009	Falling	<5	1.8	0.28	8	<0.0005	0.0064	<0.002	0.025	N/A	N/A	N/A	N/A	0.77
	3/27/2009	Rising	<5	1.6	0.20	14	<0.0005	0.006	<0.002	0.036	N/A	N/A	N/A	N/A	0.44
	3/27/2009	Peak	<5	1.0	0.13	7	<0.0005	0.0033	<0.002	0.023	N/A	N/A	N/A	N/A	0.36
	3/27/2009	Falling	<5	1.2	0.15	7	<0.0005	0.0035	<0.002	0.022	N/A	N/A	N/A	N/A	0.52
	4/4/2009	Rising	<5	1.5	0.08	10	<0.0005	0.0021	<0.002	0.015	N/A	N/A	N/A	N/A	0.71
	4/4/2009	Peak	<5	1.5	0.12	4	<0.0005	0.0046	<0.002	0.028	N/A	N/A	N/A	N/A	<0.02
	4/4/2009	Falling	<5	1.6	0.25	3	<0.0005	0.0028	<0.002	0.017	N/A	N/A	N/A	N/A	<0.02
	5/30/2009	Rising	6	1.3	0.11	2	<0.0005	0.0053	<0.002	0.15	24000	5	0.02	<5	0.47
	5/30/2009	Peak	6	2.1	0.08	3	<0.0005	0.004	<0.002	0.048	N/A	N/A	N/A	N/A	0.22
	5/30/2009	Falling	5	1.8	0.10	3	<0.0005	0.0053	<0.002	0.022	N/A	N/A	N/A	N/A	0.29
	6/19/2009	Rising	<5	1.0	0.15	1	<0.0005	0.004	<0.002	0.026	24000	5	0.04	6.8	0.71
	6/19/2009	Peak	5	1.3	0.17	3	<0.0005	0.0033	<0.002	0.023	N/A	N/A	N/A	N/A	0.31
	6/19/2009	Falling	13	2.4	0.23	14	<0.0005	0.005	<0.002	0.027	N/A	N/A	N/A	N/A	<0.02
	7/24/2009	Rising	<5	1.3	0.11	7	<0.0005	0.0039	<0.002	0.018	2400	5	<0.01	5.2	0.51
	7/24/2009	Peak	<5	1.0	0.08	3	<0.0005	0.0028	<0.002	0.02	N/A	N/A	N/A	N/A	0.33
	7/24/2009	Falling	<5	1.3	0.08	2	<0.0005	0.0029	<0.002	0.02	N/A	N/A	N/A	N/A	0.30
	9/12/2009	Rising	13	0.9	0.10	2	<0.0005	0.0052	<0.002	0.061	N/A	N/A	N/A	N/A	<0.02
	9/12/2009	Peak	<5	0.7	0.15	1	0.0005	0.0028	<0.002	0.018	N/A	N/A	N/A	N/A	0.10
	9/12/2009	Falling	5	0.8	0.17	1	<0.0005	0.0032	<0.002	0.023	N/A	N/A	N/A	N/A	0.10

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

Table 5-6c. Water chemistry results for instream baseflow monitoring at Peter Pan Run (mg/l). Fecal coliform results are in MPN/100 mL. Highlighted values indicate that results may exceed MD freshwater chronic criteria.*

ID	DATE	STAT	BOD	TKN	Phosph	TSS	Cadmium*	Copper*	Lead*	Zinc*	Colif*	TPH	Phenols	Oil+Grease	Nitrate+Nitrite
	10/13/2008	Baseflow	<5	<0.5	0.08	1	<0.0005	<0.002	<0.002	0.05	93	<5	<0.01	<5	1.9
	11/17/2008	Baseflow	<1	<0.5	0.12	2	<0.0005	<0.002	<0.002	<0.01	93	<5	<0.01	<5	1.8
	12/30/2008	Baseflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23	8.7	<0.01	5	N/A
	1/22/2009	Baseflow	<1	<0.5	0.03	1	<0.0005	<0.002	<0.002	0.011	4	<5	<2	11	3.0
	2/26/2009	Baseflow	<1	1.9	0.01	2	<0.0005	<0.002	<0.002	0.01	23	<5	<0.5	<5	2.9
	3/12/2009	Baseflow	<1	<0.5	0.01	<1	<0.0005	<0.002	<0.002	0.013	23	<5	<2	5.4	2.1
	4/24/2009	Baseflow	<1	1.2	3.7	2	<0.0005	<0.002	<0.002	0.015	43	N/A	<0.01	<5	0.87
	5/22/2009	Baseflow	<1	1.6	0.02	2	<0.0005	<0.002	<0.002	0.021	240	<5	<0.01	6.4	2.8
	6/22/2009	Baseflow	<1	1.0	0.08	3	<0.0005	<0.002	<0.002	<0.01	930	<5	<0.01	<5	2.0
	7/7/2009	Baseflow	<1	<5	0.02	<1	<0.0005	<0.002	<0.002	<0.01	750	7.2	<0.01	5.1	2.7
	8/11/2009	Baseflow	<5	1.0	0.04	<1	<0.0005	0.002	<0.002	<0.01	390	<5	<0.01	5.6	2.4
	9/14/2009	Baseflow	<1	0.8	0.05	<1	N/A	<0.002	<0.002	<0.01	230	<5	<0.01	<5	1.8

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

Table 5-7. Comparison of annual average Peter Pan Run EMCs from storms sampled between October 1, 2008 and September 30, 2009, with Maryland state average EMCs for all land uses, with values from two national datasets, and with Maryland water quality standards.

	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	3.491 - 5.023	3.555 - 4.949	14.44	9	9	4.34			
TKN	2.021 - 2.076	0.792 - 0.972	1.94	1.5	1.5	1.03			
Phosphorus	0.709	0.238	0.33	0.31	0.33	0.13			
Copper	0.0109 - 0.0112	0.0032 - 0.0033	0.0179	0.012	0.034	0.0095	0.013	0.009	1.3
TPH	0.107 - 0.509	0.000 - 0.132							
Zinc	0.057 - 0.058	0.024	0.1433	0.073	0.160	0.0644	0.12	0.12	9.1
Cadmium	0.0004 - 0.0007	0.0001 - 0.0006	0.0002	0.0005		0.0004	0.002	0.00025	0.005
Lead	0.009 - 0.010	0.0000 - 0.0020	0.0125	0.012	0.144	0.0046	0.065	0.0025	0.015
TSS	153.663 - 153.741	6.276	66.57	49	100	15.21			
Phenols	0.000 - 0.001	0.0007	7						
Nitrite plus Nitrate	1.255 - 1.256	0.314 - 0.315	0.85	0.6	0.68				
Oil and Grease	0.100 - 0.526	0.092 - 0.153		4					

[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 the detection limit.
[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.
EMC = volume-weighted event mean concentration

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 and are enclosed in Appendix C of this report.[1] Note that for the purpose of discussion, EMCs and baseflow mean concentrations (MCs) were calculated with non-detectible results set to zero.

Instream Concentrations

During WY 2009, average annual storm event mean concentrations of all pollutants increased from WY 2008 levels except for phosphorus, TPH, and oil and grease. Baseflow mean concentrations that declined compared to WY 2008 included BOD, copper, zinc, TSS, and nitrate and nitrite. The remainder increased (TPH, TKN, phosphorus, and oil and grease) or were non-detectible in both of the last two years (cadmium, lead, and phenols).

Average annual storm runoff metal concentrations increased during WY 2009 in comparison to WY 2008, but remained lower than WY 2007 values. Storm runoff concentrations of zinc increased 1.5% and copper increased 29.4% (Figure 5-12). Lead and cadmium were detected in less than half of storm samples, but their average EMCs increased by 9.9% and 42.1%, respectively (Figure 5-13). Annual baseflow zinc declined by nearly 70%. Copper was detected in just one baseflow sample during the year. Both lead and cadmium were not detected in baseflow samples from Peter Pan Run, as was the case in WY 2008.

Calculated EMCs for metals may be compared to the standards listed in Table 5-7. 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

[1]In the electronic database containing storm event mean concentrations and baseflow concentrations, the following apply: (1) storm duration (DURAT) 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 “0.999" denote samples not collected, tests not performed or field not applicable; (3) flow-weighted mean temperatures were determined by obtaining the flow-weighted mean of individual temperature measurements as taken by an *in-situ* recording device (e.g., YSI model 600-XL multiparameter 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; (4) flow-weighted mean pH values were obtained by calculating the flow-weighted mean of laboratory pH measurements on samples representing the rising, peak, and falling limbs; (5) “First flush” storm event parameters fecal coliform, phenols, TPH, and Oil and Grease are presented in the database as actual concentrations, rather than a calculated event mean.

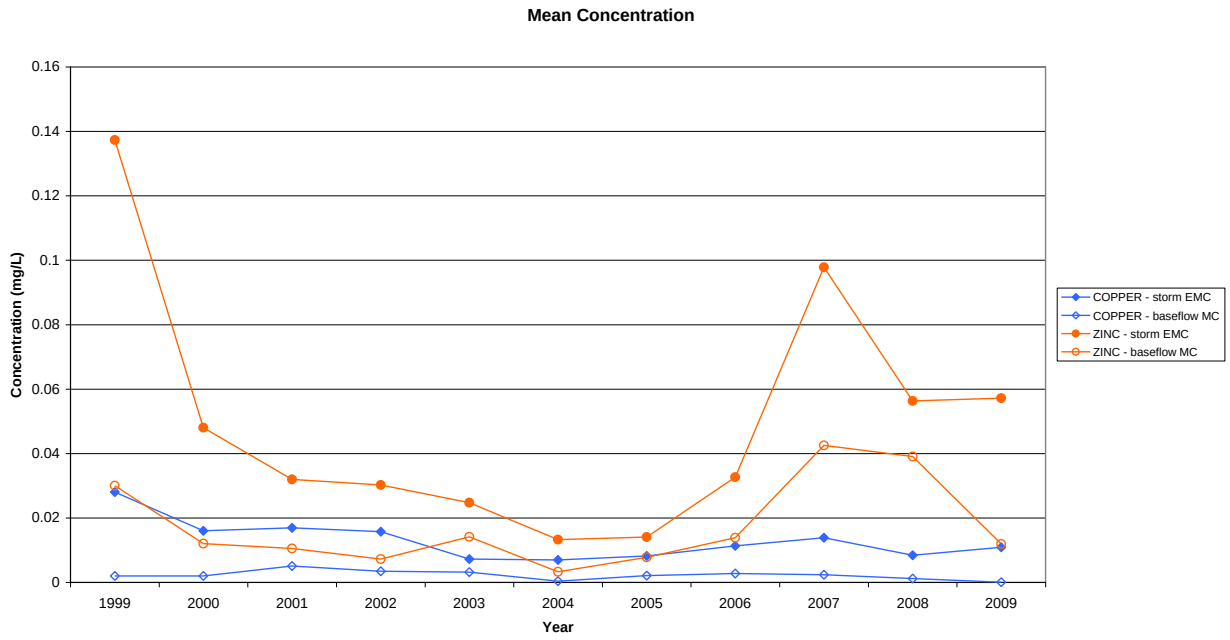

Figure 5-12. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper and zinc at Peter Pan Run instream site (WY 1999-2009).

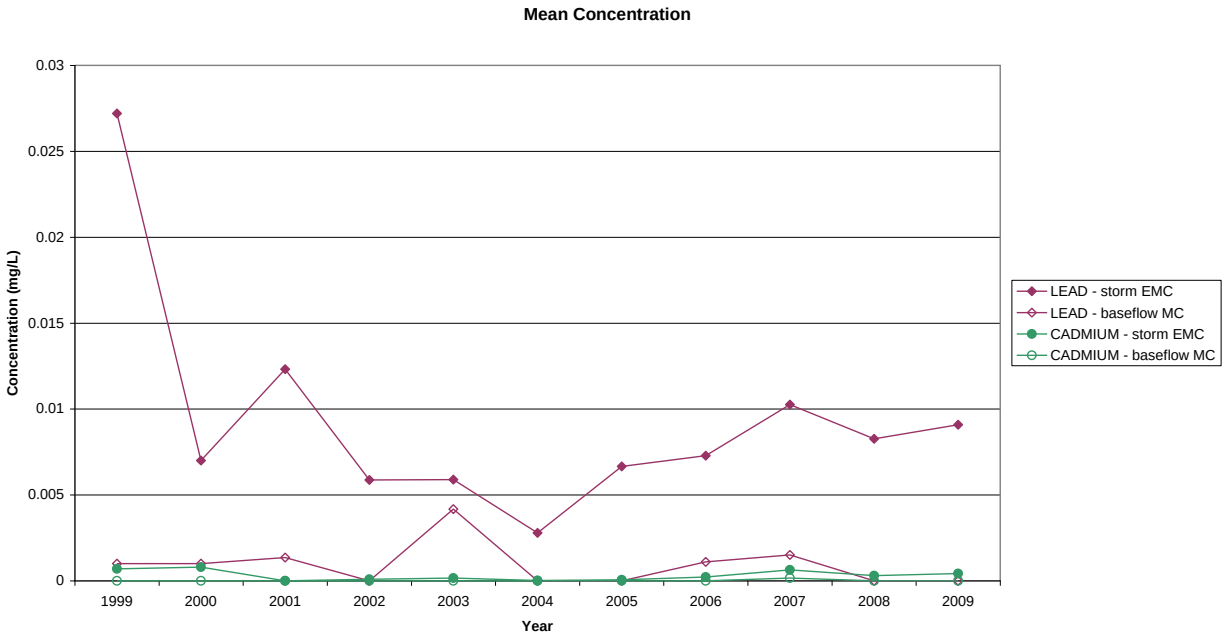

Figure 5-13. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of lead and cadmium at Peter Pan Run instream site (WY 1999-2009).

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. No average annual storm EMCs or baseflow MCs for metals exceeded their respective acute and chronic toxicity criteria, although three individual storm flow samples exceeded the acute criterion for copper, two samples exceeded the acute criterion for zinc, and one sample exceeded the acute criterion for cadmium (Figure 5-14). No baseflow samples exceeded chronic metal toxicity criteria.

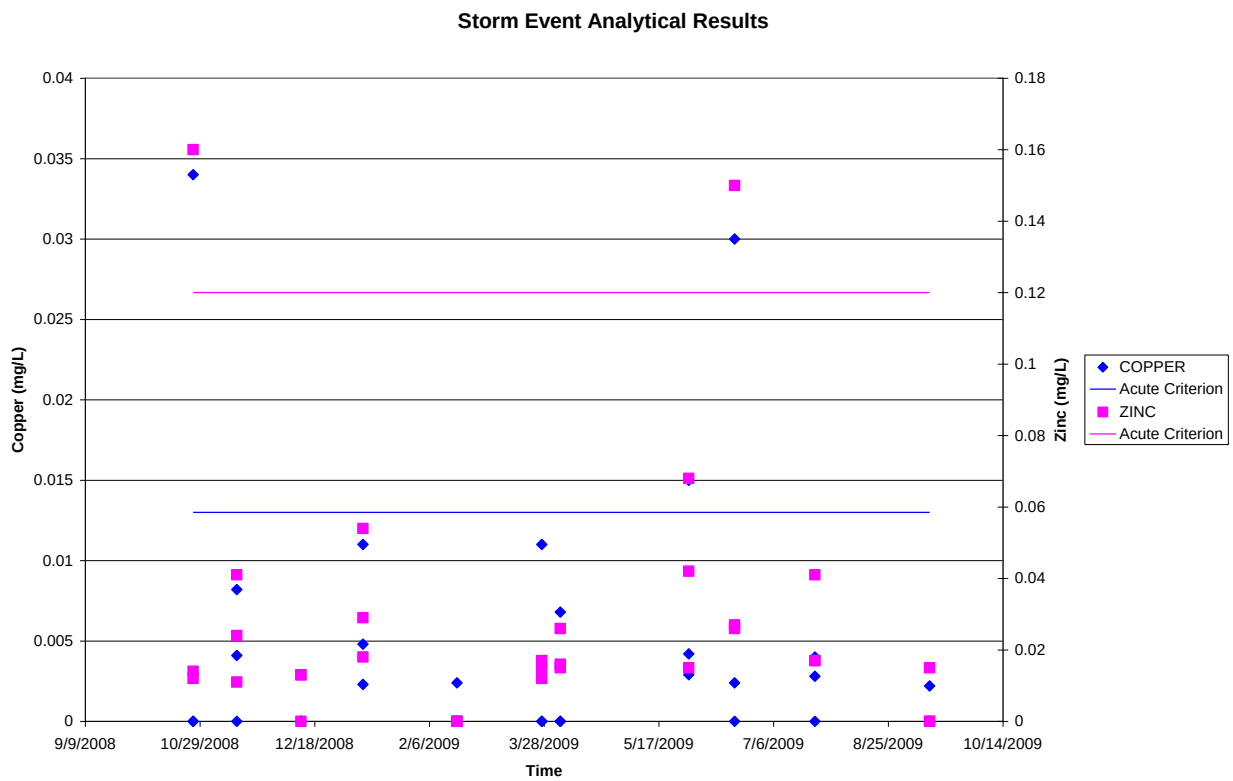

Figure 5-14. Analytical results of instream storm event total copper and total zinc in individual samples (WY 2009). Note: acute criteria are based on dissolved, rather than total concentrations. Results below detection limits are shown at zero.

Primary contributors to the detectable high metal concentrations in runoff in the watershed are probably home construction, natural sources, and automobile use. 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).

Total petroleum hydrocarbons (TPH) were above detection limits in one first flush storm and in two baseflow samples during WY 2009, but had not been detected in any instream samples in WY 2008. Phenols were not detected in either baseflow or storm runoff samples, as has been the case for nearly all monitoring years. Oil and grease was detected in one of four first flush storm samples and in five baseflow samples during WY 2009. The average baseflow MC for oil and grease increased by 31.5% in WY 2009.

Storm nitrate and nitrite concentrations increased slightly from a near-historic low annual average in WY 2008; baseflow nitrate and nitrite declined (0.4%) to a new historic low during WY 2009. Low nitrate and nitrite baseflow MCs may be indicative of reduced nitrogen input in formerly agricultural areas of the PUD. Storm flow and baseflow TKN increased to a historic or near-historic high, respectively (Figure 5-15). The average annual storm EMC for phosphorus decreased to a level comparable to results in WY 2005 and WY 2007. Average baseflow phosphorus, however, increased 10-fold to its highest level (0.9 mg/l) in the history of monitoring at the instream site, owing to a particularly high concentration in the April 24, 2009 sample. In fact, the average annual baseflow MC for phosphorus was unexpectedly higher than the storm flow EMC during WY 2009 (Figure 5-16). Storm-related average EMCs of suspended solids increased 39.2% during WY 2009, but still remained historically low and appeared to continue a generally decreasing trend over time. The average baseflow MC of TSS decreased slightly from the prior year's value to the lowest level since monitoring initiated in WY 1999 (Figure 5-17).

Elevated concentrations of fecal coliform (*i.e.*, exceeding 200 organisms/100 mL) were found in several baseflow and storm event samples (Figure 5-18), with most samples elevated at the instream station during the May to September 2009 period. The highest baseflow result was 930 organisms/100 mL in June 2009; the highest storm result of 1,200 organisms/100 mL was found in May 2009. Typical sources of fecal coliform in surface waters in a watershed include wildlife, pet waste, and malfunctioning septic or sewage treatment systems (Vann *et al.* 2002).

An ANOVA statistical test was performed on the data to compare the compiled baseflow concentrations obtained during the year to event mean concentrations of the eleven storms to determine whether storm event pollutant concentrations were significantly different than baseflow concentrations. The test results show that for contaminants for which there are both baseflow and storm flow concentrations above zero, storm flow EMCs for BOD, copper, zinc, and TSS were significantly (i.e., with greater than 95% certainty) higher than corresponding baseflow concentrations. Nitrate and Nitrite and oil and grease concentrations in baseflow were significantly higher than corresponding storm flow concentrations.

Outfall Concentrations

Storm EMCs and baseflow MCs at outfall were calculated in a similar fashion as instream for each parameter. Average annual storm EMCs at the outfall decreased over last year for eight of 12 pollutants. Note that no baseflow samples were taken at the outfall, therefore only storm EMCs are discussed below.

Figure 5-15. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at Peter Pan Run instream site (WY 1999-2009).

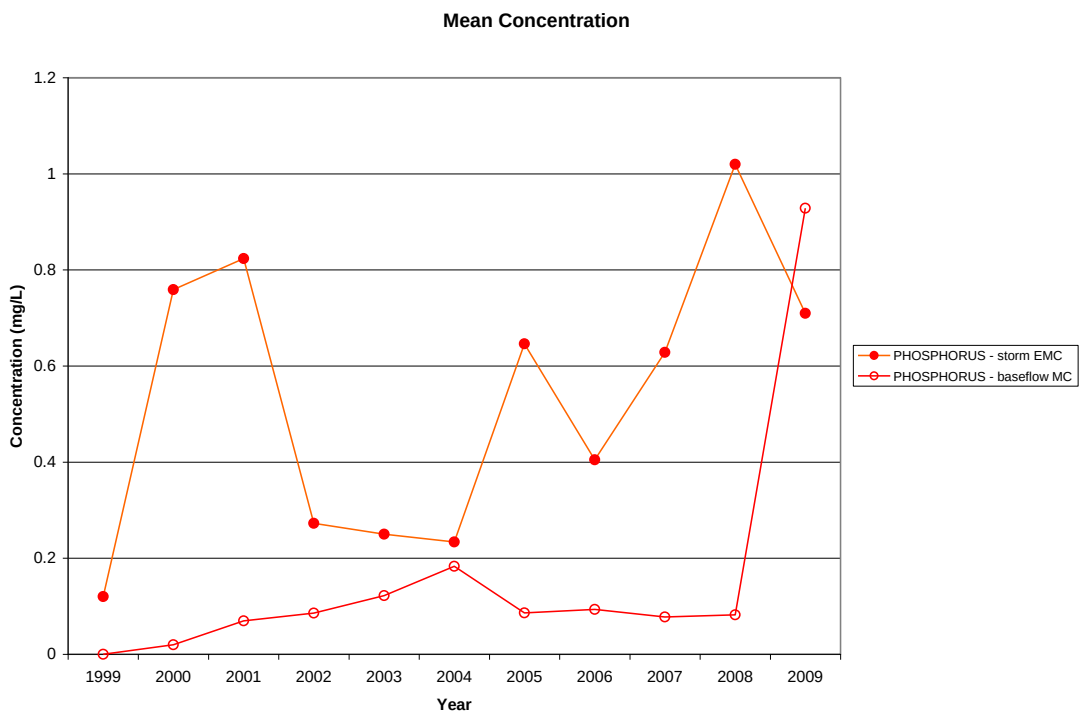

Figure 5-16. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of phosphorus at Peter Pan Run instream site (WY 1999-2009).

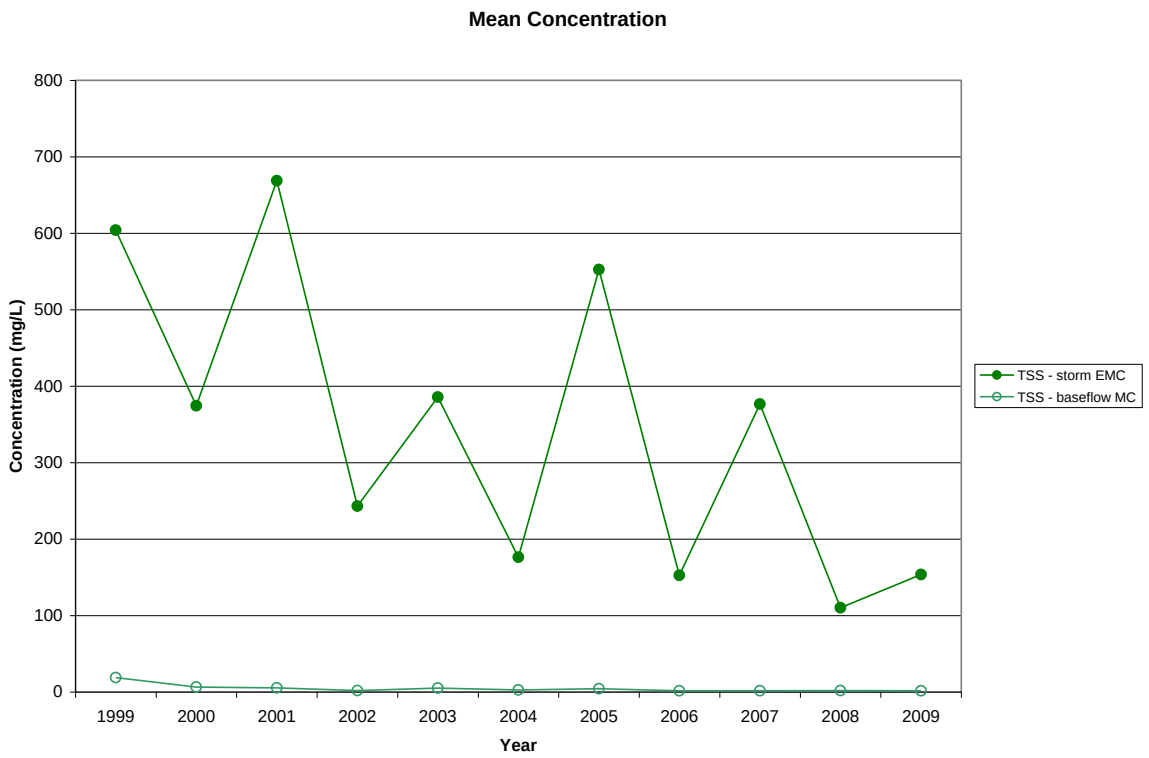

Figure 5-17. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS at Peter Pan Run instream site (WY 1999-2009).

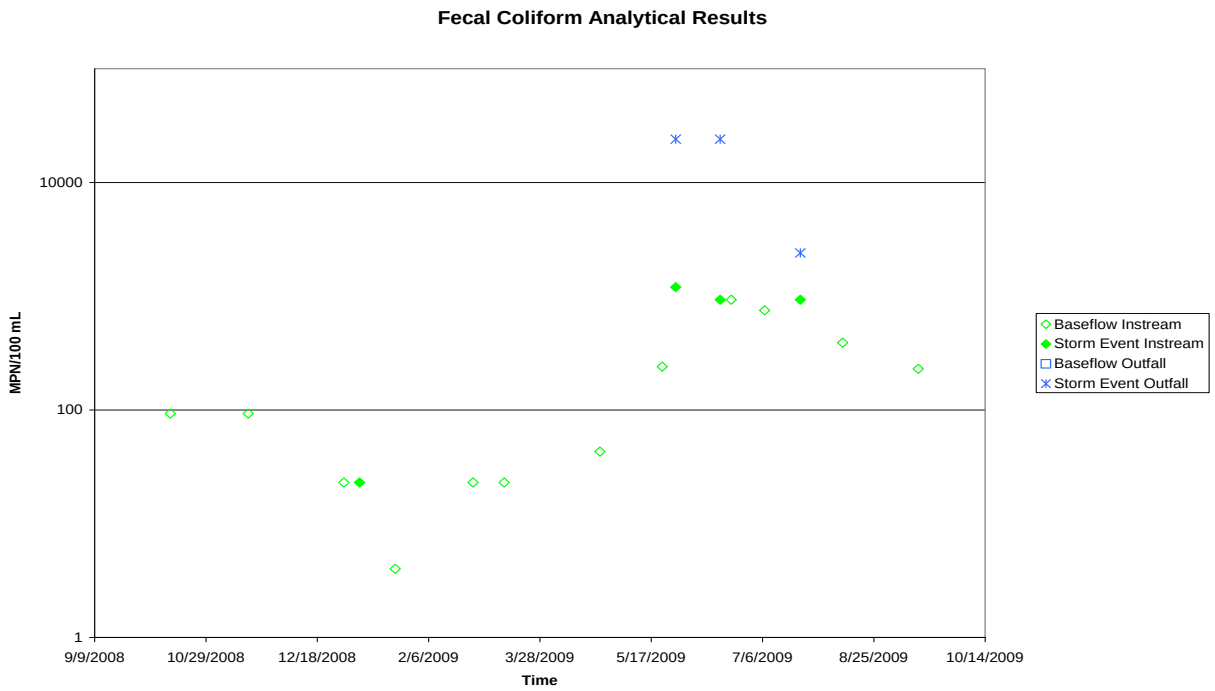

Figure 5-18. Analytical results of instream and outfall storm event and baseflow fecal coliform concentrations (WY 2009). Results below detection limits are shown at zero.

Copper and zinc were present in nearly every storm sample; however, their average storm EMCs decreased 73.2% and 59.3%, respectively for the year. The zinc EMC returned to near the WY 2006 level while the copper EMC dropped to an all-time low level (Figure 5-19). Lead was detected in just one sample while cadmium was detected in two storm runoff samples at the outfall station during WY 2009. One sample from the May 30, 2009 storm exceeded the Maryland freshwater acute criterion for zinc (Figure 5-20) and one sample from the January 8, 2009 storm exceeded the Maryland freshwater acute criterion for cadmium .

Storm EMCs for TSS and phosphorus decreased at the outfall during WY 2009 by 92.4% and 82.4%, respectively, to values comparable to WY 2007 levels. Figure 5-21 shows how closely the average phosphorus EMC follows the average TSS EMC. Storm EMCs for nitrate and nitrite increased by 1.1% compared to WY 2008. In contrast, storm TKN dropped from its all-time high level in WY 2008 by 61.5% to an EMC value comparable to WY 2007 (Figure 5-22).

Oil and grease was present in two of three storm runoff samples obtained at the outfall; TPH was not detected in any first flush samples. Phenols were not detected in any storm runoff samples during WY 2009. Each of the three first-flush storm samples that were tested for fecal coliform showed concentrations greater than the health hazard criterion of 200 organisms/100 mL (Figure 5-14). The highest storm result was 24,000 organisms/100 mL in both May and June 2009.

Average storm EMCs for all parameters were lower at outfall than at instream except for BOD. Phenols were present in outfall storm samples, but not in instream. The ANOVA test on the grouped outfall data showed that average annual storm flow EMCs for lead, nitrate and nitrite, TSS, and fecal coliform at the instream station were significantly higher than corresponding average annual storm EMCs at the outfall.

5.1.1.4 Pollutant Loading Estimates for Peter Pan Run and Pond R Outfall

Pollutant loading estimates, as required by the conditions of this Permit, have been calculated for each storm event for both the instream and outfall stations (Tables 5-8a and 5-8b). Total storm event loadings were calculated by multiplying the storm EMC for each parameter, the corresponding total volume for that storm event calculated from flow rate data collected by the ISCO flowmeter, and the appropriate conversion factor to obtain pounds. Methods for determining calculation factors are outlined in Appendix E.

Annual and seasonal loading estimates were calculated using flow and concentration data collected from both the Peter Pan Run instream station and the Pond R outfall station over a 12-month period (October 2008 through September 2009). The flow-weighted EMC for a given pollutant over a given period for all monitored storms at each site was determined from the total mass of pollutant from the monitored storms divided by total volume from the monitored storms. Tables 5-9a and 5-9b show comparative estimated results of baseflow and stormwater annual pollutant loadings at Peter Pan Run and Pond R. An analogous calculation was used to determine seasonal loading estimates. Seasonal estimates for the instream station are presented in Tables 5-10a through 5-10d and for the outfall station in Tables 5-11a through 5-11d.

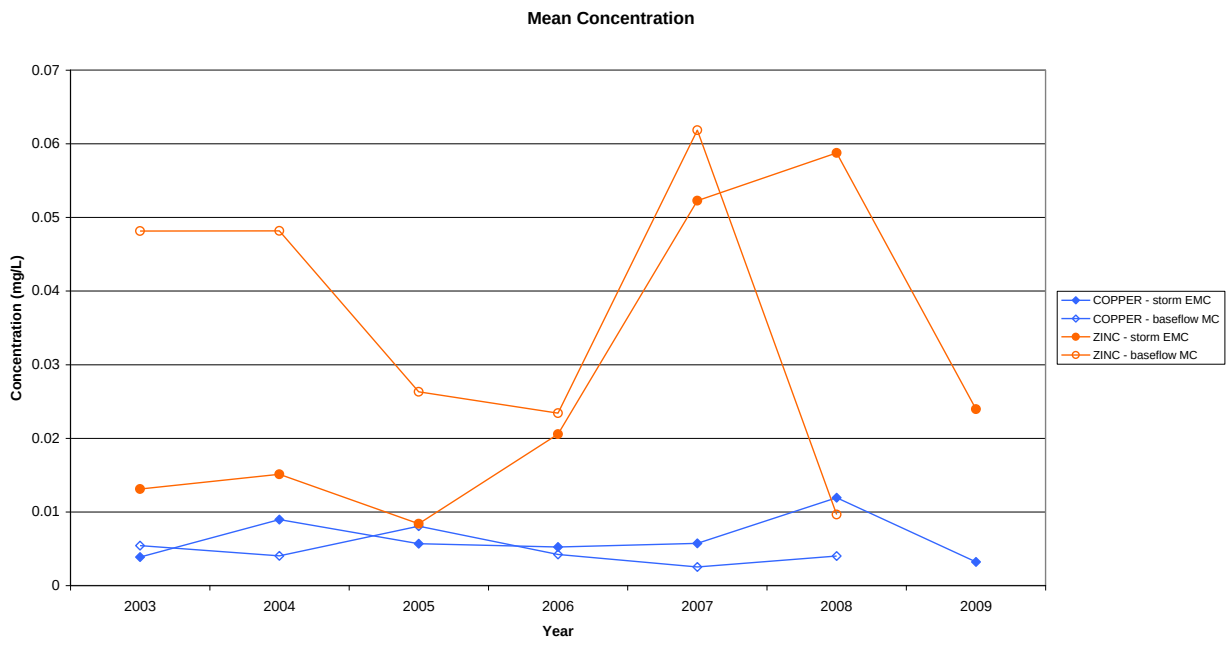

Figure 5-19. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper and zinc at Pond R outfall site (WY 2003-2009).

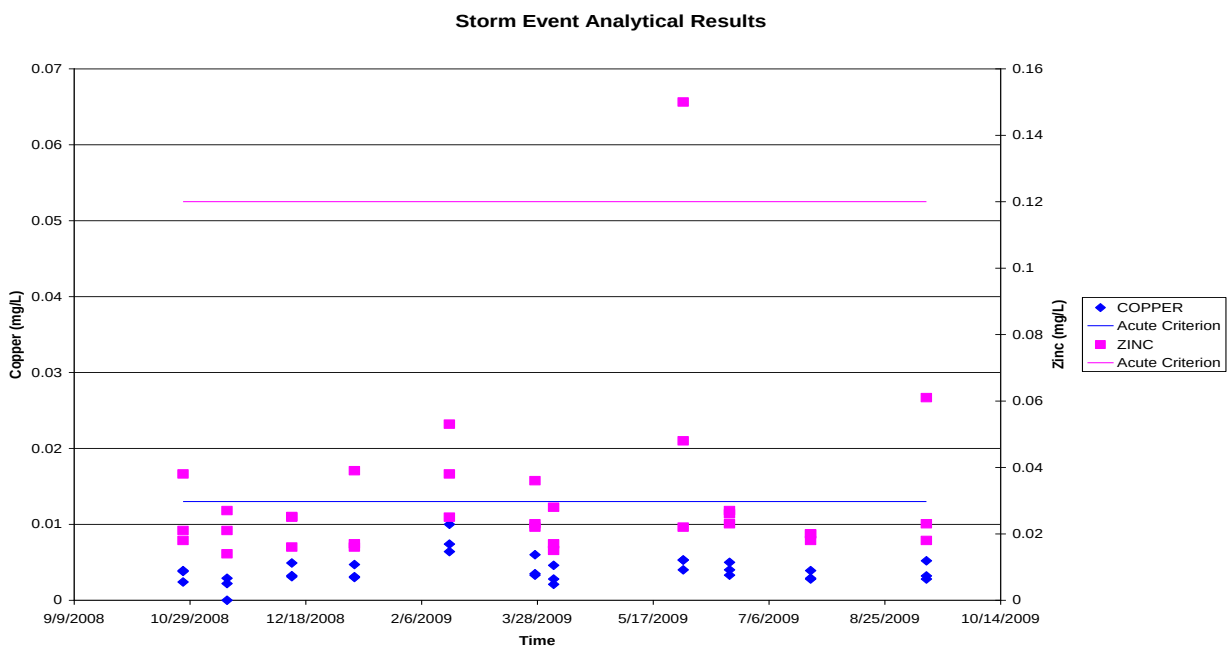

Figure 5-20. Analytical results of outfall storm event total copper and total zinc (WY 2009). Note: acute criteria are based on dissolved, rather than total concentrations. Results below detection limits are shown at zero.

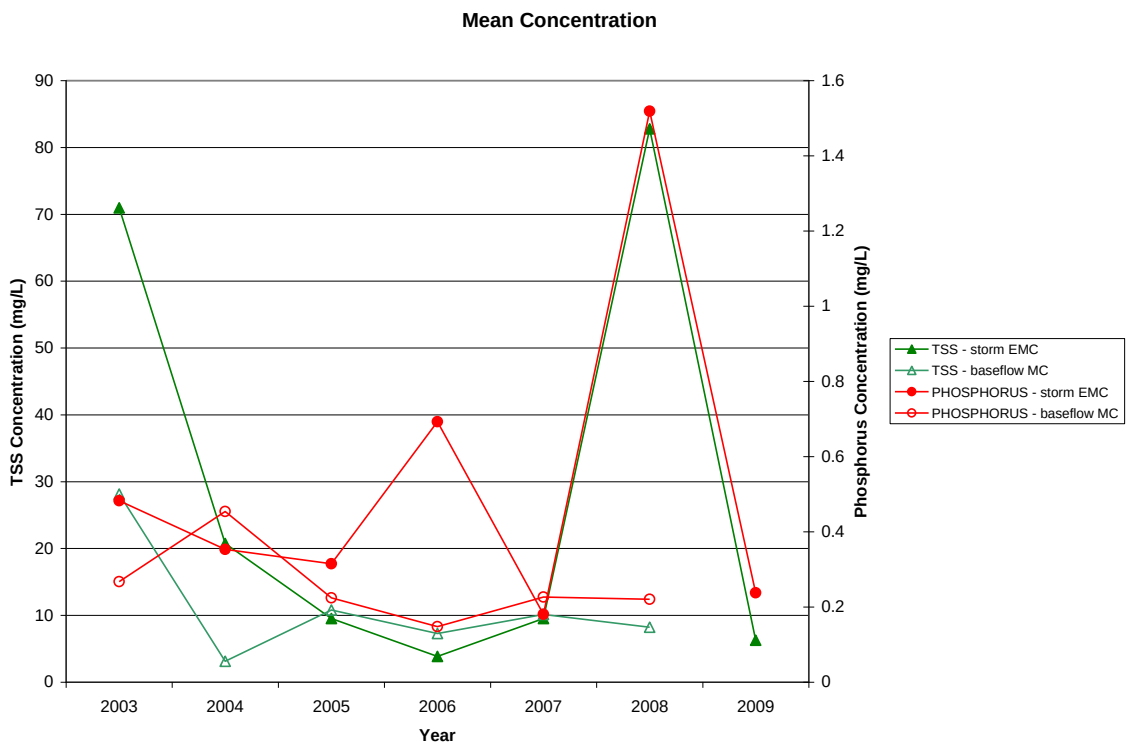

Figure 5-21. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at Pond R outfall site (WY 2003-2009).

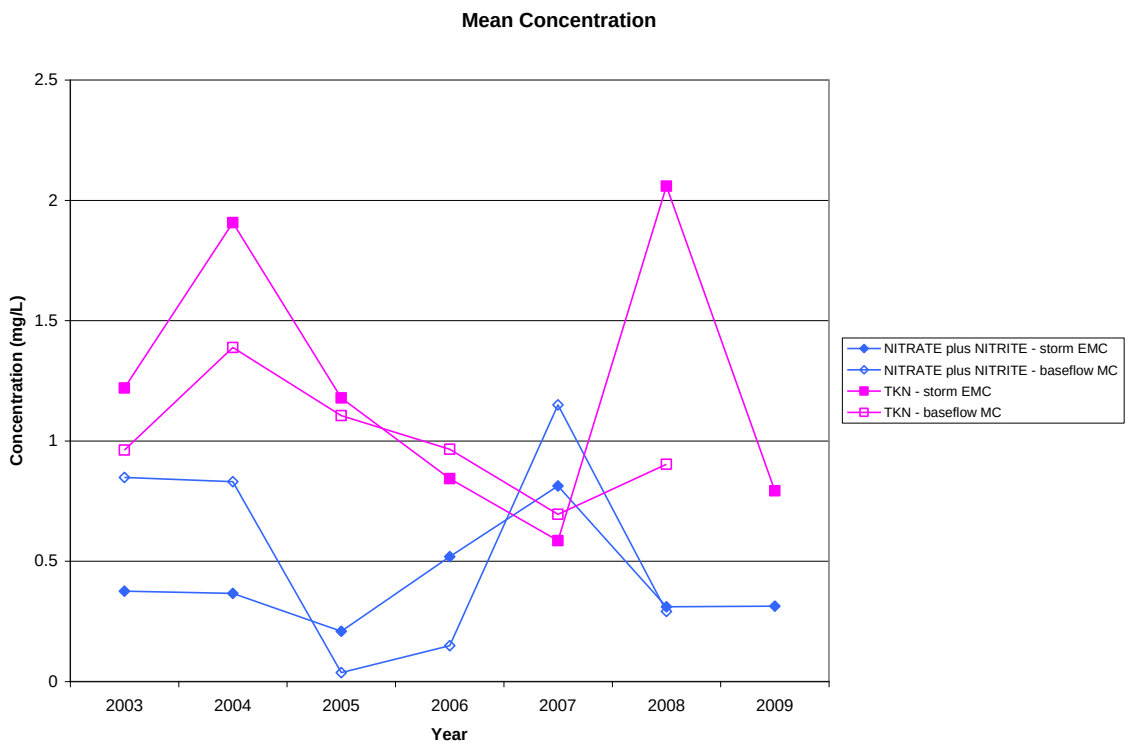

Figure 5-22. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at Pond R outfall site (WY 2003-2009).

Table 5-8a. Storm event flow in cubic feet and acre-feet. Pollutant loads in pounds per storm event at Peter Pan Run.*

Date	Total Storm Volume (acre-ft)	Total Storm Volume (cf)	BOD	TKN	Phos	Copper	TPH	Zinc	Cadmium	Lead	TSS	Phenols	Nitrate-Nitrite	Oil & Grease
10/25/2008	32.861	1,431,411	1419.88	445.49 - 461.24	276.96	1.967 - 2.030	NC	9.69	0 - 0.045	1.794 - 1.857	87715.89	NC	83.55	NC
11/14/2008	11.210	488,290	96.4 - 128.31	0.00 - 15.24	5.42	0.147 - 0.166	NC	0.86	0 - 0.025	0.210 - 0.229	609.06	NC	36.08	NC
12/12/2008	4.366	190,181	0 - 59.36	0.00 - 5.94	0.73	0 - 0.024	NC	0.10 -0.14	0 - 0.006	0 - 0.024	18.62	NC	26.80	NC
1/6/2009	50.239	2,188,395	399.94 - 411.37	379.04	164.60	1.091	66.27	5.71	0.173	0.965 - 0.988	19136.52	0 - 0.11	174.07	0 - 57.13
2/19/2009	5.621	244,864	14.52 - 24.97	15.27	1.38	0.013 - 0.033	NC	0.06 -0.15	0 - 0.008	0 - 0.031	262.23	NC	39.74	NC
3/27/2009	4.846	211,090	0.00 - 65.89	13.18	0.90	0.062 - 0.077	NC	0.19	0.008 – 0.010	0 - 0.026	187.75	NC	26.79	NC
4/4/2009	12.140	528,826	0.00 - 165.07	62.16	3.65	0.119 - 0.150	NC	0.69	0 - 0.017	0 - 0.066	1992.45	NC	14.40 - 14.75	NC
5/30/2009	38.874	1,693,356	290.25 - 550.67	202.48	26.26	0.970	0 -129.37	5.04	0 - 0.053	0.663 - 0.719	3104.96	0 - 0.26	145.19	0 -129.37
6/19/2009	46.678	2,033,275	236.47 - 284.58	136.15	27.38	2.460 - 2.477	0 - 42.35	13.08	0.056 - 0.08	2.207 - 2.303	4571.78 - 4619.89	0 - 0.08	142.20	61.83
7/23/2009	44.686	1,946,526	0.00 - 607.59	125.47	20.27	0.240 - 0.338	0 -155.64	3.06	0 - 0.061	0.156 - 0.336	17826.92	0 - 0.31	171.44	0 - 155.64
9/12/2009	5.129	223,433	0.00 - 69.74	13.88	0.85	0.012 - 0.029	NC	0.08 -0.17	0.027 - 0.031	0 - 0.028	436.85	NC	24.27	NC

NC = sample not collected.
*Where concentrations reported below detection limit, loadings are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 5-8b. Storm event flow in cubic feet and acre-feet. Pollutant loads in pounds per storm event at Pond R Outfall.*

Date	Total Storm Volume (acre-ft)	Total Storm Volume (cf)	BOD	TKN	Phos	Copper	TPH	Zinc	Cadmium	Lead	TSS	Phenols	Nitrate-Nitrite	Oil & Grease
10/26/2008	3.131	136,380	39.49	3.93 - 5.97	3.167	0.0268	NC	0.191	0 - 0.0043	0 - 0.0170	68.35	NC	2.472	NC
11/14/2008	1.676	73,012	24.74	0 - 2.28	1.023	0.0051 - 0.0103	NC	0.082	0 - 0.0023	0 - 0.0091	15.36	NC	1.980	NC
12/12/2008	0.845	36,794	0.00 - 11.48	0 - 1.15	0.292	0.0082	NC	0.053	0 - 0.0011	0 - 0.0046	9.63	NC	1.256	NC
1/8/2009	4.529	197,293	36.95	11.34 - 12.62	2.904	0.0419	NC	0.262	0.0067 - 0.0116	0 - 0.0246	109.29	NC	3.531	NC
2/18/2009	0.172	7,492	2.88 - 3.62	0.84	0.101	0.0037	NC	0.018	0 - 0.0002	0 - 0.0009	5.01	NC	0.378	NC
3/27/2009	0.250	10,876	0.00 - 3.39	0.79	0.100	0.0026	NC	0.017	0 - 0.0003	0 - 0.0014	5.44	NC	0.294	NC
4/4/2009	0.535	23,323	0.00 - 7.28	2.23	0.218	0.0048	NC	0.030	0 - 0.0007	0 - 0.0029	7.93	NC	0.304	NC
5/30/2009	1.134	49,376	17.38	5.41	0.296	0.015	0 - 4.54	0.212	0 - 0.0015	0 - 0.0062	8.34	0.02	0.983	0 - 4.54
6/19/2009	3.678	160,200	34.35 - 71.14	15.71	1.845	0.038	0 - 3.38	0.243	0 - 0.005	0 - 0.0200	57.72	0.03	2.551 - 2.604	4.59
7/24/2009	2.263	98,562	0.00 - 30.77	6.94	0.509	0.018	0 - 2.75	0.122	0 - 0.0031	0 - 0.0123	18.57	NC	2.067	2.86
9/12/2009	0.683	29,734	4.26 - 10.50	1.38	0.280	0.0057	NC	0.042	0.0006 - 0.0009	0 - 0.0037	2.01	NC	0.170 - 0.173	NC

NC = sample not collected.
*Where concentrations reported below detection limit, loadings are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 5-9a. Baseflow and stormflow concentrations with estimated annual baseflow and stormflow loads in Peter Pan Run*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated WY 2009 Load (lbs)
BOD	3.491 - 5.023	0 - 1.563	13,333 - 19,186	0 - 3,384	13,333 - 22,570
TKN	2.021 - 2.076	0.749 - 1.136	7,721 - 7,929	1,621 - 2,458	9,342 - 10,387
Phosphorus	0.709	0.928	2,710	2,009	4,719
Copper	0.0109 - 0.0112	0 - 0.002	42 - 43	0 - 4	42 - 47
TPH	0.107 - 0.509	1.520 - 5.605	409 - 1,945	3,290 - 12,130	3,699 - 14,075
Zinc	0.057 - 0.058	0.012 - 0.016	218 - 220	26 - 35	244 - 255
Cadmium	0.0004 - 0.0007	0 - 0.0005	2 - 3	0 - 1	2 - 4
Lead	0.009 - 0.010	0 - 0.002	35 - 38	0 - 4	35 - 42
TSS	153.663 - 153.741	1.616 - 1.799	586,932 - 587,229	3,498 - 3,894	590,430 - 591,123
Phenols	0.000 - 0.001	0 - 0.204	0 - 4	0 - 442	0 - 446
Nitrate + Nitrite	1.255 - 1.256	1.898	4,795 - 4,797	4,108	8,902 - 8,905
Oil + Grease	0.100 - 0.526	1.530 - 5.420	382 - 2,008	3,311 - 11,730	3,693 - 13,739

* 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.

Table 5-9b. Baseflow and stormflow concentrations with estimated annual baseflow and stormflow loads in Pond R Outfall*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated WY 2009 Load (lbs)
BOD	3.555 - 4.949		646 - 899		646 - 899
TKN	0.792 - 0.972		144 - 176		144 - 176
Phosphorus	0.238		43		43 - 43
Copper	0.0032 - 0.0033		0.58 - 0.61		0.58 - 0.61
TPH	0 - 0.132		0 - 24		0 - 24
Zinc	0 0.024		4		4 - 4
Cadmium	0.0001 - 0.0006		0.03 - 0.11		0.03 - 0.11
Lead	0 - 0.0020		0.0 - 0.4		0.0 - 0.4
TSS	6.276		1,140 - 1,140		1,140 - 1,140
Phenols	0.0007		0.1 - 0.1		0.1 - 0.1
Nitrate+Nitrite	0.314 - 0.315		57.0 - 57.2		57.0 - 57.2
Oil + Grease	0.092 - 0.153		17 - 28		17 - 28

* 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.

Table 5-10a. Baseflow and stormflow concentrations with estimated fall (October-December 2008) baseflow and stormflow loads in Peter Pan Run*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated Fall Load (lbs)
BOD	10.051 - 11.063	0.000 - 1.774	9,842 - 10,832	0 - 1,189	9,842 - 12,021
TKN	2.877 - 3.190	0.000 - 0.500	2,817 - 3,123	0 - 335	2,817 - 3,458
Phosphorus	1.847	0.104	1,808	70	1,878
Copper	0.014 - 0.015	0.000 - 0.002	14 - 15	0 - 1	14 - 16
TPH	0.000	2.784 - 6.184	0	1,865 - 4,143	1,865 - 4,143
Zinc	0.0717 - 0.0722	0.020 - 0.026	70.2 - 70.7	13 - 17	84 - 88
Cadmium	0.0000 - 0.0005	0.0000 - 0.0005	0.0 - 0.5	0.0 - 0.3	0.0 - 0.8
Lead	0.0135 - 0.0144	0.000 - 0.002	13 - 14	0 - 1	13 - 15
TSS	572.211	1.598	560,278	1,070	561,348
Phenols	0.000	0.000 - 0.010	0	0 - 7	0 - 7
Nitrate+Nitrite	1.195	1.840	1,170	1,233	2,402
Oil + Grease	0.000	0.000 - 5.000	0	0 - 3,349	0 - 3,349

* 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.

Table 5-10b. Baseflow and stormflow concentrations with estimated winter (January-March 2009) baseflow and stormflow loads in Peter Pan Run*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated Winter Load (lbs)
BOD	2.595 - 2.986	0.000 - 1.000	1,123 - 1,292	0 - 571	1,123 - 1,864
TKN	2.520	0.773 - 1.070	1,090	442 - 611	1,532 - 1,702
Phosphorus	1.044	0.017	452	10	461
Copper	0.0072 - 0.0073	0.000 - 0.002	3.1 - 3.2	0 - 1	3 - 4
TPH	0.416	0.000 - 5.000	180	0 - 2,857	180 - 3,037
Zinc	0.037	0.011	16	6	22 - 23
Cadmium	0.0011 - 0.0012	0.0000 - 0.0005	0.48 - 0.51	0.0 - 0.3	0.5 - 0.8
Lead	0.0061 - 0.0065	0.000 - 0.002	2.6 - 2.8	0.0 - 1.1	3 - 4
TSS	122.294	1.157 - 1.407	52,915	661 - 804	53,576 - 53,719
Phenols	0.0000 - 0.0007	0.000 - 1.390	0.0 - 0.3	0 - 794	0 - 794
Nitrate+Nitrite	1.435	2.735	621	1,563	2,184
Oil + Grease	0.000 - 0.358	5.126 - 7.160	0 - 155	2,929 - 4,092	2,929 - 4,247

* 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.

Table 5-10c. Baseflow and stormflow concentrations with estimated spring (April-June 2009) baseflow and stormflow loads in Peter Pan Run*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated Spring Load (lbs)
BOD	2.054 - 4.016	0.000 - 1.000	3,671 - 7,177	0 - 572	3,671 - 7,749
TKN	1.580	1.203	2,823	688	3,512
Phosphorus	0.218	1.997	390	1,142	1,532
Copper	0.012 - 0.013	0.000 - 0.002	22.3 - 22.6	0 - 1	22 - 24
TPH	0.000 - 0.720	0.000 - 5.000	0 - 1,287	0 - 2,860	0 - 4,147
Zinc	0.066	0.011 - 0.014	118	7 - 8	125 - 126
Cadmium	0.0002 - 0.0006	0.0000 - 0.0005	0.3 - 1.0	0.0 - 0.3	0.3 - 1.3
Lead	0.010 - 0.011	0.000 - 0.002	18 - 19	0 - 1	18 - 20
TSS	35.868 - 36.017	2.306	64,101 - 64,367	1,319	65,420 - 65,686
Phenols	0.000 - 0.001	0.000 - 0.010	0 - 3	0 - 6	0 - 8
Nitrate+Nitrite	1.156 - 1.158	1.528	2,067 - 2,069	874	2,941 - 2,943
Oil + Grease	0.192 - 0.781	1.034 - 5.226	342 - 1,395	592 - 2,990	934 - 4,385

* 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.

Table 5-10d. Baseflow and stormflow concentrations with estimated summer (July-September 2009) baseflow and stormflow loads in Peter Pan Run*

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)	Storm Load (lbs)	Baseflow Load (lbs)	Total Estimated Summer Load (lbs)
BOD	0.000 - 5.000	0.000 - 2.107	0 - 3,822	0 - 680	0 - 4,502
TKN	1.012	0.617 - 2.109	773	199 - 680	972 - 1,454
Phosphorus	0.108	0.038	82	12	95
Copper	0.001 - 0.002	0.0006 - 0.0020	1 - 2	0.2 - 0.6	1 - 2
TPH	0.000 - 0.564	2.149 - 5.657	0 - 431	693 - 1,825	693 - 2,256
Zinc	0.014 - 0.018	0.000 - 0.010	11 - 14	0 - 3	11 - 17
Cadmium	0.0011 - 0.0015	0.0000 - 0.0005	0.8 - 1.1	0.0 - 0.2	0.8 - 1.3
Lead	0.001 - 0.002	0.000 - 0.002	0.4 - 1.8	0.0 - 0.6	0.4 - 2.4
TSS	82.129	0.000 - 1.000	62,779	0 - 323	62,779 - 63,102
Phenols	0.000 - 0.001	0.000 - 0.010	0.0 - 0.9	0 - 3	0 - 4
Nitrate+Nitrite	1.595	2.235	1,219	721	1,940
Oil + Grease	0.000 - 0.564	3.072 - 5.196	0 - 431	991 - 1,676	991 - 2,107

* 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.

Table 5-11a. Baseflow and stormflow concentrations with estimated fall (October-December 2008) baseflow and stormflow loads in Pond R Outfall[a]

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)[b]	Storm Load (lbs)	Baseflow Load (lbs)[b]	Total Estimated Winter Load (lbs)
BOD	4.223 - 4.908		395 - 459		395 - 459
TKN	0.269 - 0.617		25 - 58		25 - 58
Phosphorus	0.297		28		28
Copper	0.0026 - 0.0030		0.2 - 0.3		0.2 - 0.3
TPH	0.000		0		0
Zinc	0.021		2		2
Cadmium	0.000 - 0.001		0.00 - 0.05		0.00 - 0.05
Lead	0.000 - 0.002		0.0 - 0.2		0.0 - 0.2
TSS	6.201		580		580
Phenols	0.000		0		0
Nitrate+Nitrite	0.366		34		34
Oil + Grease	0.000		0		0

[a] 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.
[b] No baseflow samples were taken during fall 2008.

Table 5-11b. Baseflow and stormflow concentrations with estimated winter (January-March 2009) baseflow and stormflow loads in Pond R Outfall[a]

	Average Storm EMC (mg/l)	Average Baseflow MC (mg/l)[b]	Storm Load (lbs)	Baseflow Load (lbs)[b]	Total Estimated Spring Load (lbs)
BOD	3.016 - 3.229		55 - 59		55 - 59
TKN	0.959 - 1.056		18 - 19		18 - 19
Phosphorus	0.232		4		4
Copper	0.004		0.07		0.07
TPH	0.000		0		0
Zinc	0.022		0.4		0.4
Cadmium	0.0005 - 0.0009		0.01 - 0.02		0.01 - 0.02
Lead	0.000 - 0.002		0.00 - 0.04		0.00 - 0.04
TSS	8.911		163		163
Phenols	0.000		0		0
Nitrate+Nitrite	0.310		6		6
Oil + Grease	0.000		0		0

[a] 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.
[b] No baseflow samples were taken during winter 2009.

Table 5-11c. Baseflow and stormflow concentrations with estimated spring (April-June 2009) baseflow and stormflow loads in Pond R Outfall[a]					
	Average Storm EMC (mg/l)	**Average Baseflow MC (mg/l)[b]**	**Storm Load (lbs)**	**Baseflow Load (lbs)[b]**	**Total Estimated Summer Load (lbs)**
BOD	3.549 - 6.674		80 - 150		80 - 150
TKN	1.601		36		36
Phosphorus	0.166		4		4
Copper	0.004		0.09		0.09
TPH	0.000 - 0.514		0 - 12		0 - 12
Zinc	0.032		0.7		0.7
Cadmium	0.0000 - 0.0005		0.00 - 0.01		0.00 - 0.01
Lead	0.000 - 0.002		0.00 - 0.04		0.00 - 0.04
TSS	5.193		117		117
Phenols	0.003		0.07		0.07
Nitrate+Nitrite	0.263 - 0.268		5.91 - 6.02		5.91 - 6.02
Oil + Grease	0.339 - 0.604		8 - 14		8 - 14

[a] 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.
[b] No baseflow samples were taken during spring 2009.

Table 5-11d. Baseflow and stormflow concentrations with estimated summer (July-September 2009) baseflow and stormflow loads in Pond R Outfall[a]					
	Average Storm EMC (mg/l)	**Average Baseflow MC (mg/l)[b]**	**Storm Load (lbs)**	**Baseflow Load (lbs)[b]**	**Total Estimated Summer Load (lbs)**
BOD	1.454 - 5.417		49 - 181		49 - 181
TKN	0.883		30		30
Phosphorus	0.126		4		4
Copper	0.0030		0.1		0.1
TPH	0.000 - 0.164		0 - 5		0 - 5
Zinc	0.022		0.7		0.7
Cadmium	0.0002 - 0.0005		0.01 - 0.02		0.01 - 0.02
Lead	0.000 - 0.002		0.00 - 0.07		0.00 - 0.07
TSS	1.793		60		60
Phenols	0.0000 - 0.0003		0.00 - 0.01		0.00 - 0.01
Nitrate+Nitrite	0.181 - 0.182		6.06 - 6.09		6.06 - 6.09
Oil + Grease	0.171		6		6

[a] 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.
[b] No baseflow samples were taken during summer 2009.

Annual, estimated pollutant loadings at the instream station increased compared to estimates in WY 2008 for all parameters except zinc (decreased 15.1% to 244 lbs) and phenols (decreased to zero lbs). The increases in loadings for the remaining pollutants were driven mostly by higher

overall stormflow and pollutant concentrations in the current year. Lower MCs for many pollutants coupled with lower annual total baseflow in the watershed were not sufficient to counteract upward-trending storm flow-driven loadings. In the current year, BOD posted the greatest increase in loading (143% to 13,300 lbs) between WY 2008 and WY 2009. Remaining metals loadings increased between 33.2% and 72.4% (i.e., to 1.63 lbs for cadmium, 41.7 lbs for copper, and 34.7 lbs for lead). The phosphorus loading estimate decreased by 37.1% while TSS decreased by approximately twice the percentage, suggesting that the ratio of phosphorus to TSS continued to increase in WY 2009. Of the remaining nutrients, nitrate and nitrite increased 14.5% (7,800 lbs to 8,900 lbs) and TKN increased 83.3% (5,100 lbs to 9,300 lbs) from the prior year.

At outfall, estimated polluting loadings declined for 10 of 12 parameters, in most cases by over 80%, compared to prior year levels. The main cause of the reductions was lower EMCs for most pollutants and lower total discharge in WY 2009. Note, however, that for cadmium and lead, the annual loading is based on at most two samples with above-detection-limit results taken during the entire monitoring year. Copper and zinc estimated loadings declined by 83.3% and 82.2%, respectively, from WY 2008 levels. Phosphorus declined by 93.2% along with TSS (96.7%). The loading of nitrate plus nitrite in WY 2009 declined less precipitously by 56.5%. BOD was one of only two parameters at outfall that increased during the current year, by approximately three-fold. Phenols also increased from no detections in WY 2009 to two. The estimated loading of oil and grease decreased by 89.3% while TPH dropped to zero, as it was not present in any samples taken. Note that phenols, TPH, and oil and grease loadings have as their basis a limited number of positive sample results. For parameters that were detected in samples during WY 2009, the estimated contribution of Pond R to the total loading of the watershed ranged from between 0.003% (lead) and 4.8% (BOD).

Seasonal loadings were calculated for each parameter at each station during the monitoring year. Absent from consideration are parameters collected irregularly, such as phenols, TPH, and oil and grease. Six of the remaining nine parameters at the instream station were highest during the spring season. Seasonal cadmium loadings were highest in the summer while seasonal phosphorus and BOD were highest in the fall. Maximum seasonal EMCs occurred during fall for most parameters; however, maximum storm and total discharge occurred in spring, leading to higher total loadings for most parameters in spring compared to other seasons of the year. Seasonal loadings for pollutants have tended to increase or decrease from levels in the prior year depending on whether total discharge increased or decreased. For example, total discharge increased 73.3% in the fall season of WY 2009 compared to WY 2008; therefore, most parameters' loadings increased during WY 2009 in the fall. During summer, total discharge decreased 24.7% and consequently most of the pollutant loadings decreased as well.

5.1.2 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 date. The following is a summary of the biological data collected at the four Peter Pan Run stream monitoring stations in 2009 (Figure 5-2). Data from this year's survey, along with data from past years, have been compiled in Appendix F.

Benthic sampling, qualitative habitat assessments, quantitative geomorphic assessments of physical habitat, including cross-section surveys and pebble counts were conducted March 10 and March 11, 2009, within the spring index period for benthos. Summer sampling activities were conducted on September 9 and September 15, 2009 and included water quality testing, 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, prepared by Morgan and Roth (2005), 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 presents a plan for gathering high-quality, accurate data that will meet a study or project's objectives and goals. It provides a useful reference when questions arise about field or laboratory procedures.

Benthic macroinvertebrate and fish data were collected and used to calculate Index of Biotic Integrity (IBI) scores for each of the four stations in the Peter Pan Run watershed. The MBSS's updated fish and benthic IBI formulations were used to score all sites (Southerland et al. 2005). All IBI scores calculated using older methods were recalculated using the refined IBIs so that the recent scores could be compared to historical data (Appendix F). It should be noted that previous IBI ratings for individual sites may change when recalculated using the new IBI; however, these differences appear to be minor when looking at collective scores across a watershed. In addition, the new IBI is considered to provide an improved interpretation of site conditions. The former fish IBI was developed after the first round of the MBSS and scores could not be calculated for sites with catchment areas smaller than 300 acres. The second round of the MBSS almost doubled the number of sites for MBSS to draw on when developing the updated IBI (Southerland et al. 2005). An increased statewide pool of MBSS sites, with a larger number of small headwater streams, allowed for a more sensitive IBI that enables scoring of these smaller tributaries. The IBI scores are divided into four classes as shown in Table 5-12. Benthic and fish data collected in this round of sampling were used to calculate the IBI scores summarized in Table 5-13.

Table 5-12. Scoring classes for the Index of Biotic Integrity used by the MBSS indices

Class	Range
Good	4.0 - 4.9
Fair	3.0 - 3.9
Poor	2.0 - 2.9
Very Poor	1.0 - 1.9

Table 5-13. Summary of 2009 results from Peter Pan Run using the MBSS 2005 IBIs

Station	Benthic IBI Score	Benthic IBI Rating	Fish IBI Score	Fish IBI Rating
PPAN-01	2.25	Poor	3.67	Fair
PPAN-02	2.25	Poor	3.67	Fair
PPAN-03	2.25	Poor	3.33	Fair
PPAN-04	1.50	Very Poor	1.67	Very Poor

In 2009, the benthic IBI (BIBI) ratings were in the Poor category for all sites, except for PPAN-04, which rated as Very Poor. PPAN-02 and PPAN-03 had both rated in the Fair category in 2008, while rating Poor in previous years. PPAN-04 had moved out of the Very Poor category, and had been rated as Poor since 2005. The number of taxa found at each site was similar to those collected in 2008. The lower numbers of taxa in 2007 for the sites were consistent with those seen when the streams were suffering from drought conditions in 2003. After the previous low taxa numbers were recorded, it took two years before streams recovered and taxa numbers rebounded. Populations seem to be rebounding more quickly after the 2007 drought. As a result of changing field collection and analysis methods at the beginning of 2001, benthic data collected prior to 2001 are similar, but not directly comparable to the current data.

Data from the summer electrofishing surveys were used to calculate fish IBI (FIBI) scores for each Peter Pan Run station (Table 5-13). Fish IBI scores dropped at PPAN-01 and PPAN-02, from Good to Fair in 2008, and remained in the Fair category for 2009. PPAN-03 scored in the Fair category, as it has since 2000. After scoring in the Poor category from 2006 through 2008, PPAN-04 was once again was rated as Very Poor. However, despite the change in category at PPAN-04, numeric FIBI values did not change much from previous years. FIBI scores at all sites have remained fairly consistent since 1999, either remaining in the same category or moving back and forth between the same two categories each year. Other metrics of fish community health, including number of taxa, number of fish captured, and percentage of tolerant individuals, were in line with results from previous years. These numbers indicate a stable fish community that is able to withstand fluctuations in stream conditions. In context with previous years' data, this shows that biota were affected but able to withstand the full extent of the drought. The record setting drought and precipitation conditions during 2002 and early 2003 likely caused significant environmental stress to biota, possibly masking or exacerbating any changes that may have occurred as a result of construction and/or stormwater impacts during this period. While it is still unclear what the long-term impacts of construction and the resulting landscape changes may be, fish populations appear to have rebounded after the severe weather conditions of those two years.

In situ water quality monitoring was performed during the spring and summer visits of 2009. Values for temperature, pH, and conductivity were consistent with those of previous years, and all were within a normal range. In the summer, when DO concentrations tend to decrease due to elevated water temperatures, levels were still in a range typically considered healthy for aquatic biota. There was a spike in PPAN-04's turbidity level in April 2007, which coincided with a release of water from the stormwater management pond upstream of the site. Turbidity values had returned to the expected level when the site was visited in June 2007 for summer sampling. This year's turbidity levels were in line with prior years.

5.1.3 Physical Stream Assessment

Physical stream conditions within Peter Pan Run in 2009 were generally similar to those in years past, though certain stream parameters are beginning to show a pattern of incremental change over time. A summary of historical and current data may be found in Appendix F. Field surveys are typically performed at least 24 hours after a major storm event and when conditions approximate baseflow.

Embeddedness increased in PPAN-04 in previous years (from 25% in 2002 to 75% in 2005), and the site experienced a corresponding decline in epifaunal substrate quality. Fine sediments had filled in around much of the cobble and gravel that previously provided attachment sites and habitat for benthic macroinvertebrates and small fish. This change may have been associated with ongoing construction upstream of the site. In 2006, embeddedness decreased and epifaunal substrate quality improved at PPAN-04. Embeddedness at the site increased again to 90% in 2007, and remained at 90% in 2009. The fluctuations over the years suggest that much of the buildup causing the embedded condition are fine sediments that accumulate on the stream bottom, but then are periodically flushed out during higher flow conditions. A similar situation occurred in PPAN-03 in 2008 and 2009, with small changes in embeddedness triggering a corresponding change in epifaunal substrate quality. This may be linked to the clearing of trees from the riparian area near the site and increased bank erosion.

Stream slope at all stations is low gradient. Stream gradient has remained stable at PPAN-01 and PPAN-04 during the past four years. Aside from 2001, when PPAN-02 appeared to have aggraded, stream slope in 2009 was the same as in years past. In April 2000, slope at PPAN-03 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. Since then, slope at this station has remained stable.

Cross-sectional surveys at monumented locations within each station, and bank pins installed to measure bank erosion rates show the changes that have occurred to the channel in Peter Pan Run since 1999. Bank instability was measured at all stations, using bank pins to track new erosion. The banks at PPAN-01 continued to erode in 2009, though not significantly (8 cm of bank loss measured). Previously, measurements at PPAN-01 for 2005 and 2006 recorded the two greatest amounts of bank loss in a single year (30 cm and 29 cm, respectively; Figure 5-23).

The cross sectional survey at PPAN-01 shows that the channel has continued to widen (by 1.8 feet to the left between 2003 and 2005, and by an additional 2 feet since 2005) as a large gravel bar has filled in the center and the right half of the channel (Figure 5-24). At PPAN-02, the cross sectional profile shows that material was removed by downward scouring during 2004 (Figure 5-25). Beginning in 2007 and continuing in 2009, the area along the right bank that had been scoured out has filled in (possibly due, in part, to slumping of the right bank), and the channel has widened to the left. Downward scouring that was occurring on the right bank has been exacerbated by a large fallen tree that is lying across the stream at the cross-section, creating a pool at this location (tree was omitted from cross-sectional survey and does not appear in Figure 5-25). Continued changes in the cross sectional profiles of PPAN-03 and PPAN-04 suggested only minor alterations within their channels (Appendix F). Previous data had indicated that PPAN-04 was downcutting slightly, as evidenced by increased values for stream slope and average thalweg depth, and the decreased average channel width.

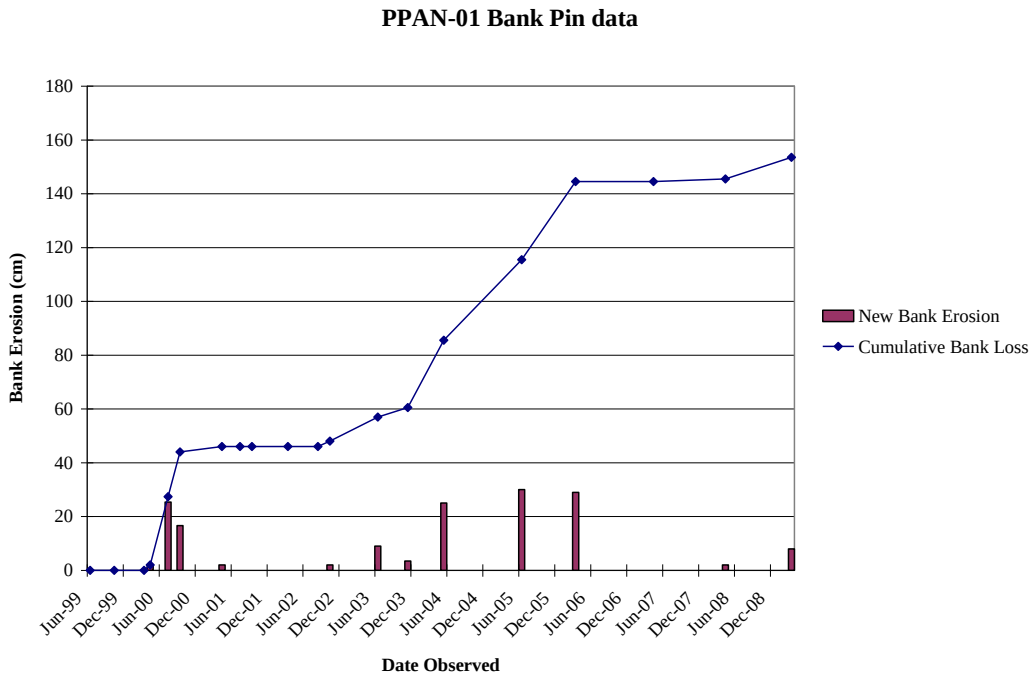

Figure 5-23. Bank loss as measured by the bank pin at PPAN-01. Note that the right bank has eroded 153.5 cm (5.0 feet) between June 1999 and April 2009.

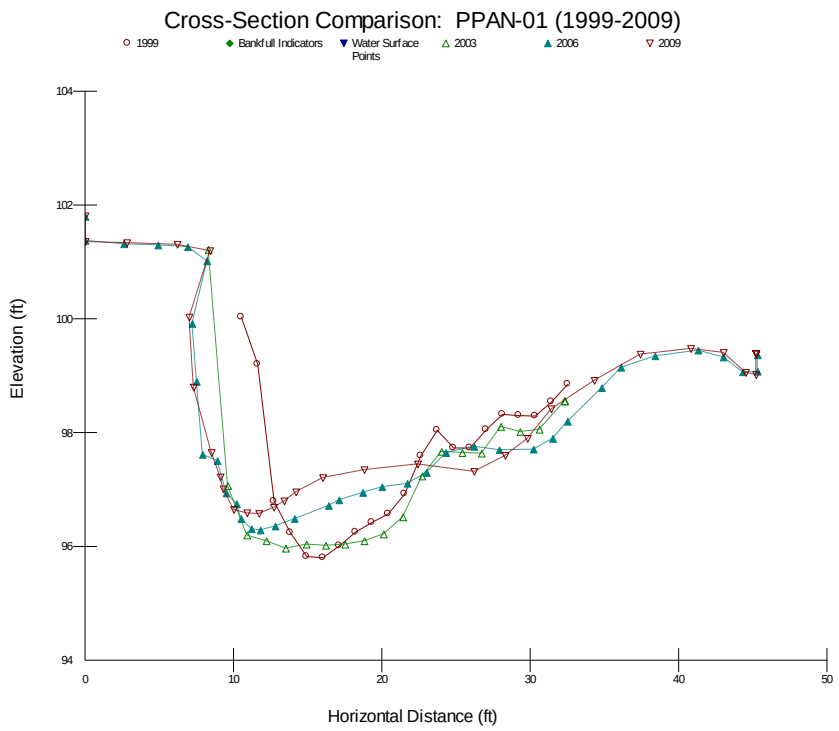

Figure 5-24. Cross sectional changes at PPAN-01 between 1999 and 2009. Note that the cross-section is shown facing downstream.

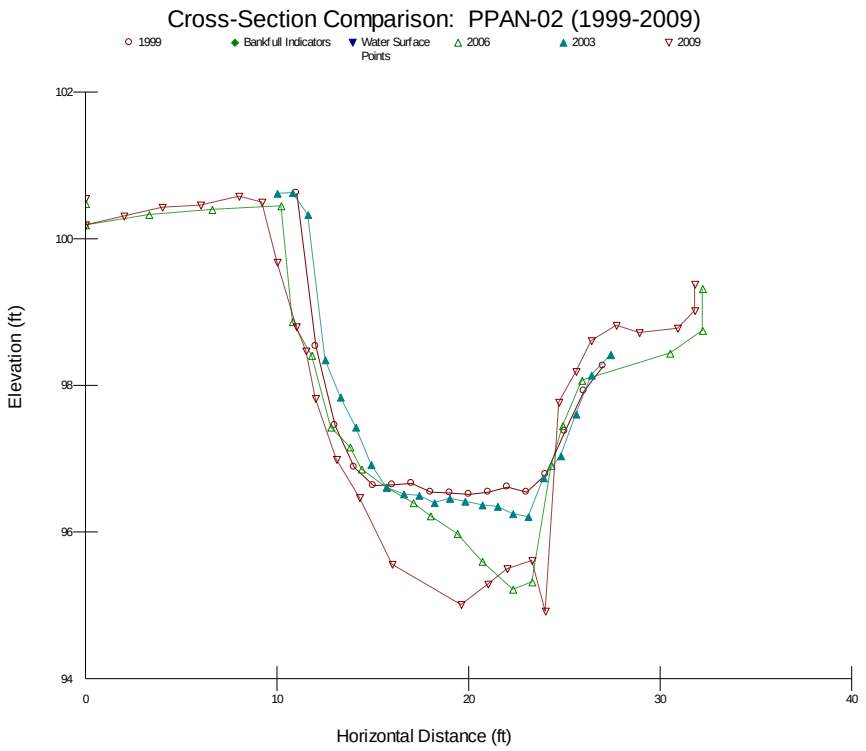

Figure 5-25. Cross sectional changes at PPAN-02 between 1999 and 2009. Note that the cross-section is shown facing downstream. The tree lying in the channel at the cross-section has been omitted from the survey profile.

A quantitative survey of stream sediments was used at each Peter Pan station to identify the median substrate particle size (D50). Wolman pebble count data indicate that, in 2001, much finer sediments began to appear at the four stations (Figure 5-26), a shift in substrate size that coincides with increased land clearing and development upstream in the Villages of Urbana. In 2003, substrate particle size was notably larger at the four stations than in previous years, which is likely the result of substrate sorting by higher flows in the first half of WY 2003 and the completion of construction in some areas of the development. Results for 2007 showed a slight increase in the D50 for all sites, with coarse gravel being the median particle size. In 2009, there was a decrease in particle size measured at PPAN-01 and an increase in particle size at PPAN-04. However, these changes are minor and median particle sizes remain in the gravel range.

5.1.4 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.

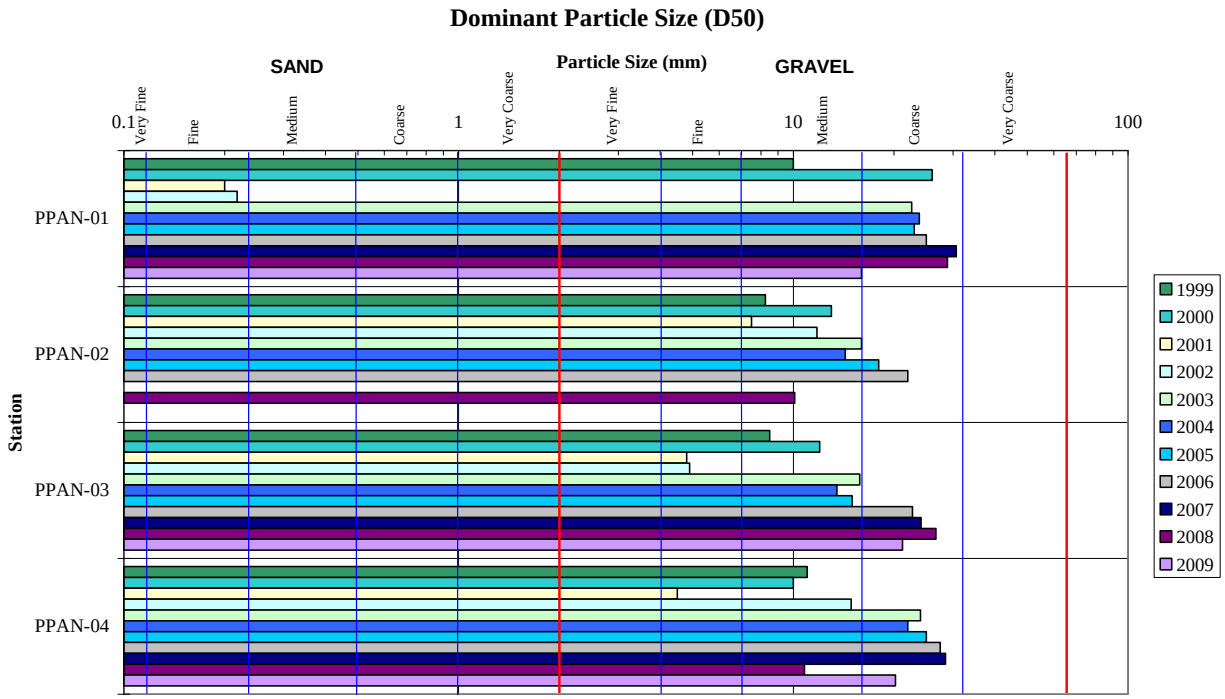

Figure 5-26. Dominant substrate particle size at Peter Pan Run stations, from June 1999 to April 2009.

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 and two very wet years.

These development and weather factors present a complex set of variables acting on 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; the effects of historical and pre-development land use activities within the catchment are also evident.

5.1.4.1 Hydrology and Water Chemistry

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 WY 1999 to present. A Kendall Tau b test for trend (Kendall, 1948) on the individual storm EMC data showed a statistically significant trend for nitrate and nitrite only.

Individual storm EMC data for metals are presented in Figure 5-27 and Figure 5-28. Loading estimates for metals during WY 2009 were between 3.0% and 62.8% higher than during WY 1999. Annual estimated loadings for phosphorus and TKN were 37 times and 62 times higher, respectively, in WY 2009 than in WY 1999. Sediment concentrations (TSS) in the stream in WY 2009 were, on average, approximately 95 times higher during storms than at baseflow, compared to approximately 32 to 217 times higher in prior years. In other terms, annual load estimates for Peter Pan Run indicate that 590,000 pounds of sediment (measured as TSS) washed down the stream in the past year, with 99.4% carried in storm flow. Annual loadings of TSS have fluctuated between 260,000 pounds and 1,750,000 pounds since 1999. Though average annual TSS EMCs have gradually declined since the onset of monitoring, annual loadings estimates show no apparent trend (Figure 5-29).

For both baseflow and storms at the instream station, concentrations of nitrogen measured as nitrate plus nitrite have nearly always been greater than 1 mg/l, (see storm EMCs, Figure 5-30). This concentration level is generally indicative of nitrogen contributions from anthropogenic sources (Roth, et al. 1999). Annual loading estimates for phosphorus appear to be gradually increasing, reflecting a general increase in average annual phosphorus EMCs since WY 2004. Individual storm EMCs for phosphorus (Figure 5-28) appear to be generally increasing in response to several high sample analysis results since WY 2004, but statistically the upward trend is not significant. A cluster of elevated phosphorus concentrations occurred early in the monitoring period (WY 1999 to 2001), and many correspond to elevated TSS concentrations that may be associated with the initial stages of mass grading and early development. Since WY 2004, the correlation of phosphorus to TSS individual storm EMCs was higher (66%) than during the period prior to WY 2004 (48%; Figure 5-31).

At outfall, individual storm EMCs for nitrate and nitrite, zinc, TSS, and phosphorus declined shortly after the conversion of Pond R from a sediment basin to a SWM facility in July 2004 (Figures 5-32 through 5-34), but only TSS and phosphorus have remained lower since WY 2004 and WY 2005. Annual loadings estimates peaked during WY 2004 for zinc, copper, phosphorus, TKN, BOD, TSS, and nitrate and nitrite and again in WY 2008 for zinc, copper, lead, phosphorus, TKN, BOD, TSS, and nitrate and nitrite. Generally, most nitrate and nitrate concentrations at outfall were below 1 mg/l, indicating a lack of anthropogenic contribution, although sporadic concentrations above 1 mg/l have been noted in WY 2006 and WY 2007. The Kendall Tau b test of individual storm EMCs of all pollutants showed that TSS and nitrate and nitrite were on a significantly declining trend over time. Individual storm EMCs of phosphorus at the outfall site showed less of a correlation with TSS concentration than at the instream station (Figure 5-35).

5.1.4.2 Physical Habitat

Physical habitat, namely increased bank erosion and sediment deposition, appears to be the most substantially affected element within the monitoring program as a result of disturbance from upstream construction. While construction impacts are likely to be short term, no signs of recovery were noted in the field data. The channel does not presently appear to be morphologically stable. Historical and pre-development land use activities within the catchment are also a factor influencing current stream conditions.

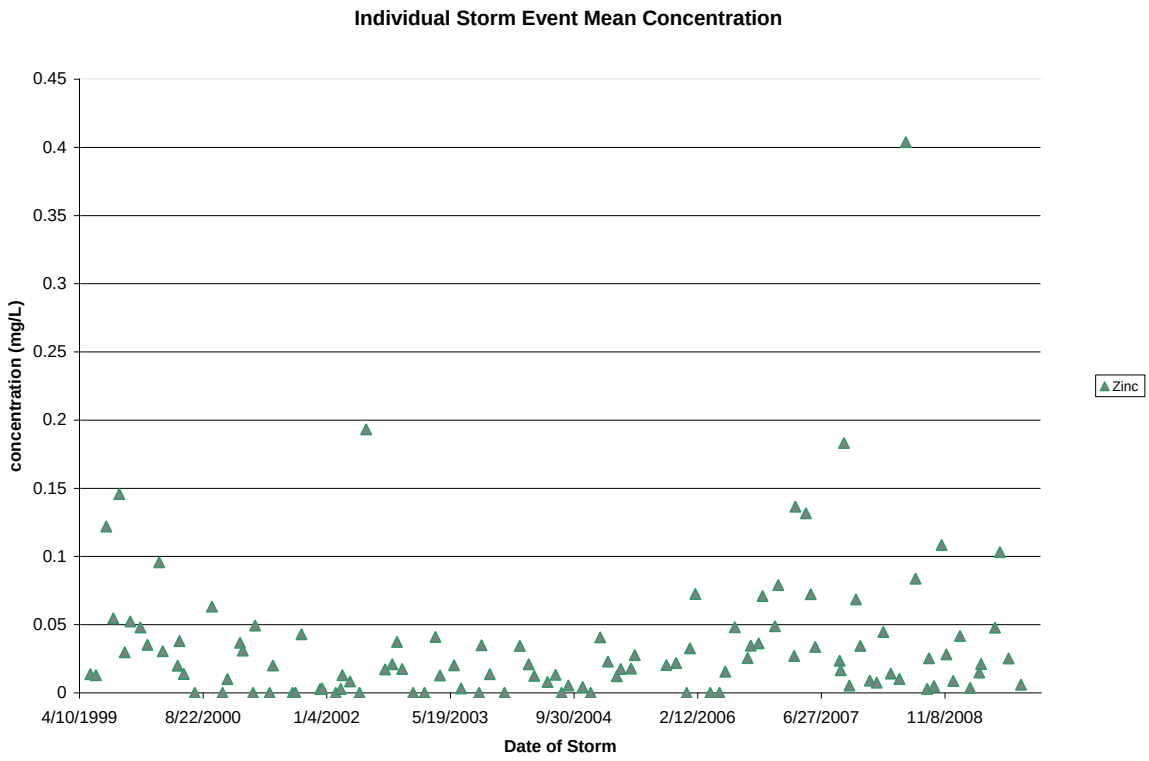

Figure 5-27. Storm event mean concentrations for zinc (May 1999 to September 2009) at the instream station. Values below detection limit are set to zero.

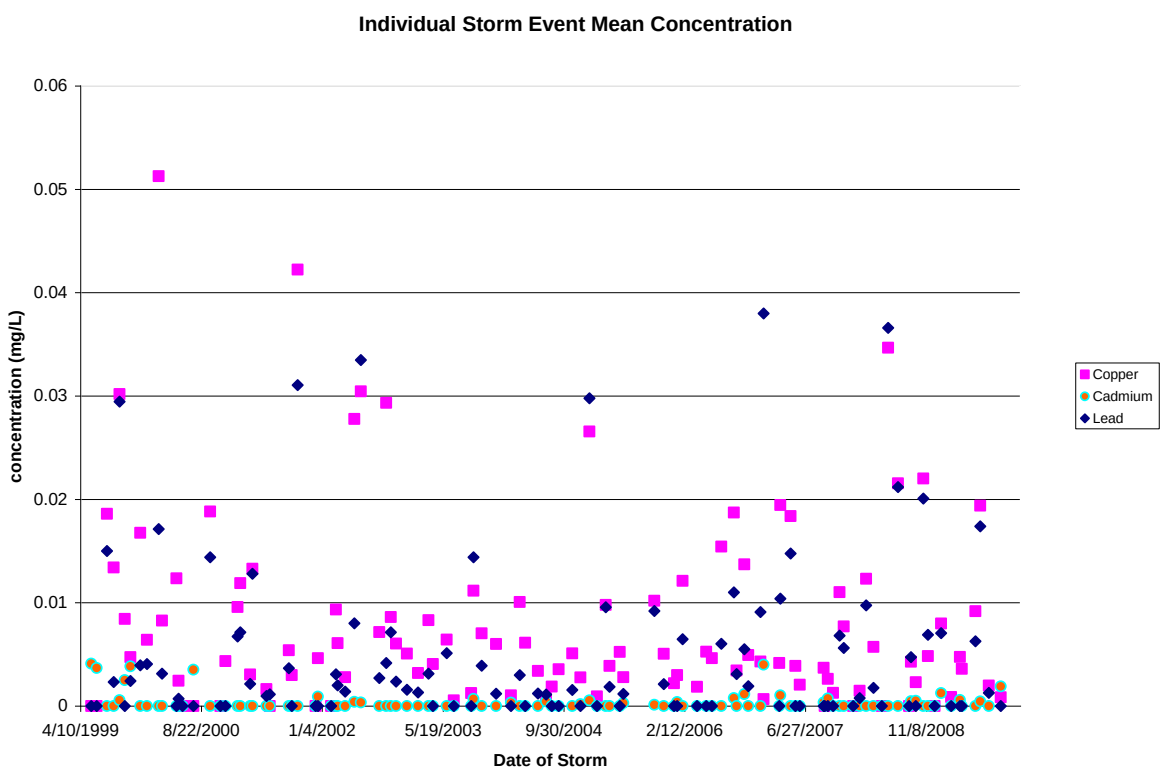

Figure 5-28. Storm event mean concentrations for copper, cadmium, and lead (May 1999 to September 2009) at the instream station. Values below detection limit are set to zero.

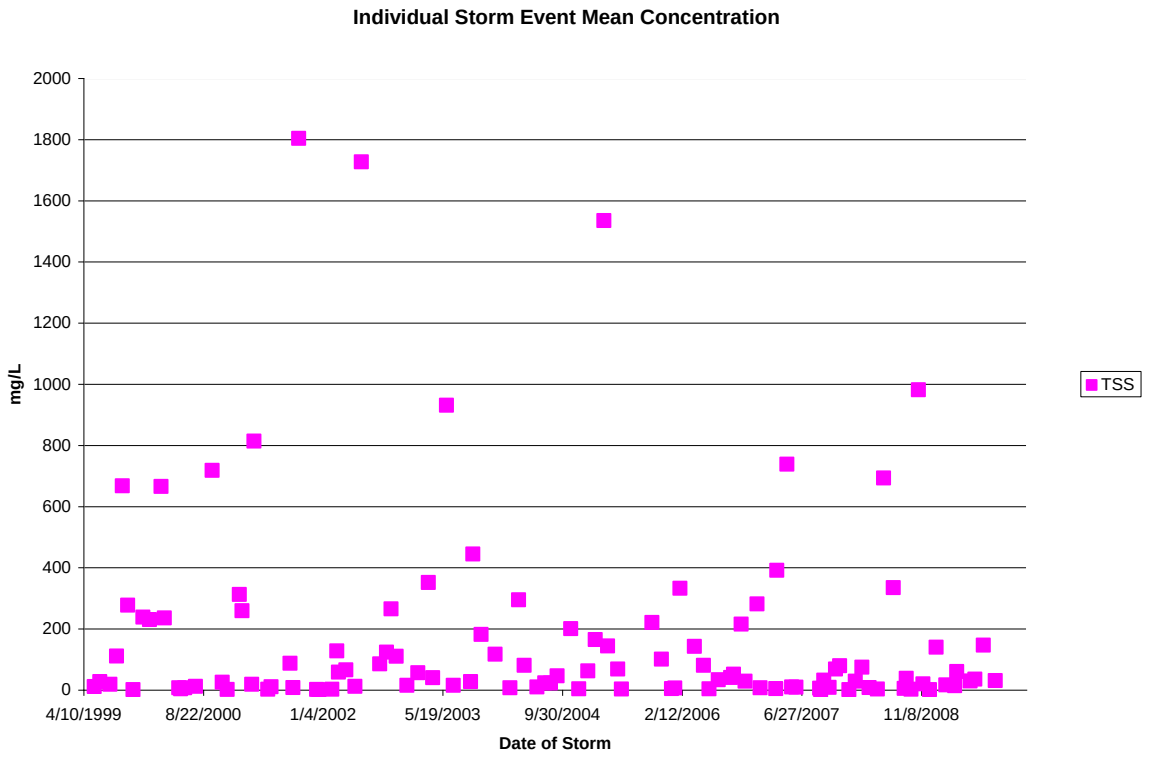

Figure 5-29. Storm event mean concentrations for TSS (May 1999 to September 2009) at the instream station.

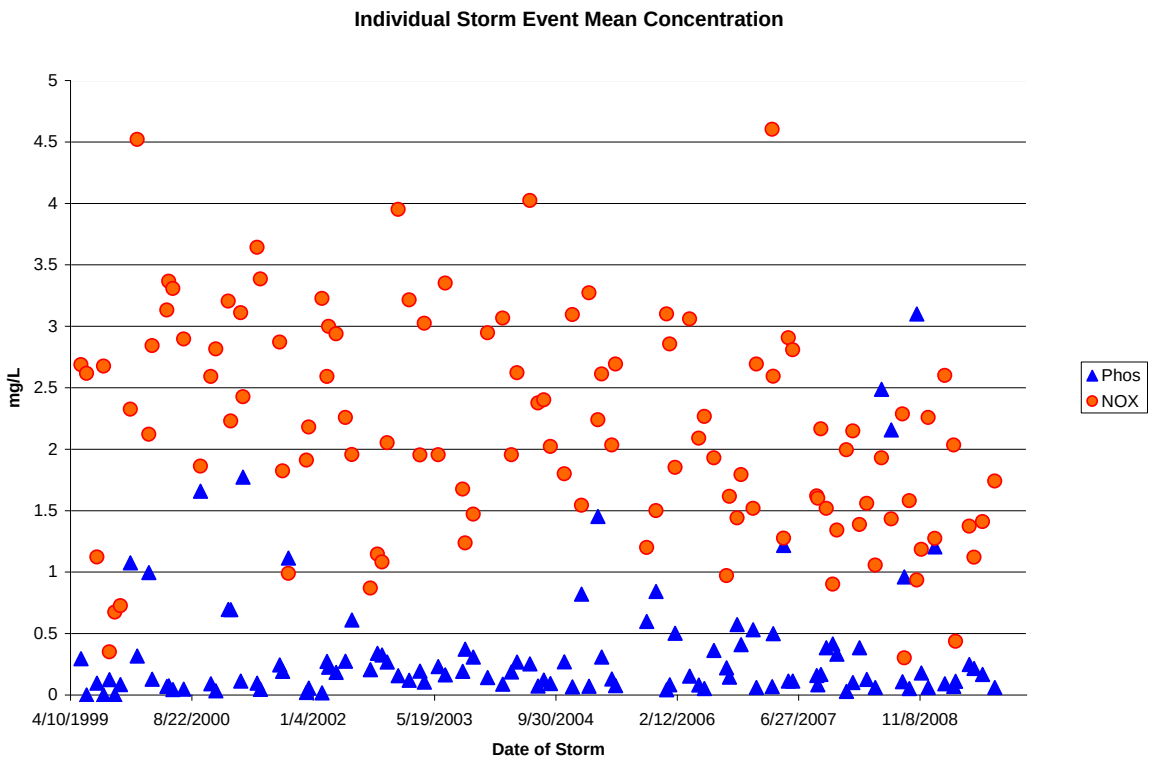

Figure 5-30. Storm event mean concentrations for phosphorus and nitrate + nitrite (May 1999 to September 2009) at the instream station. Values below detection limit are set to zero.

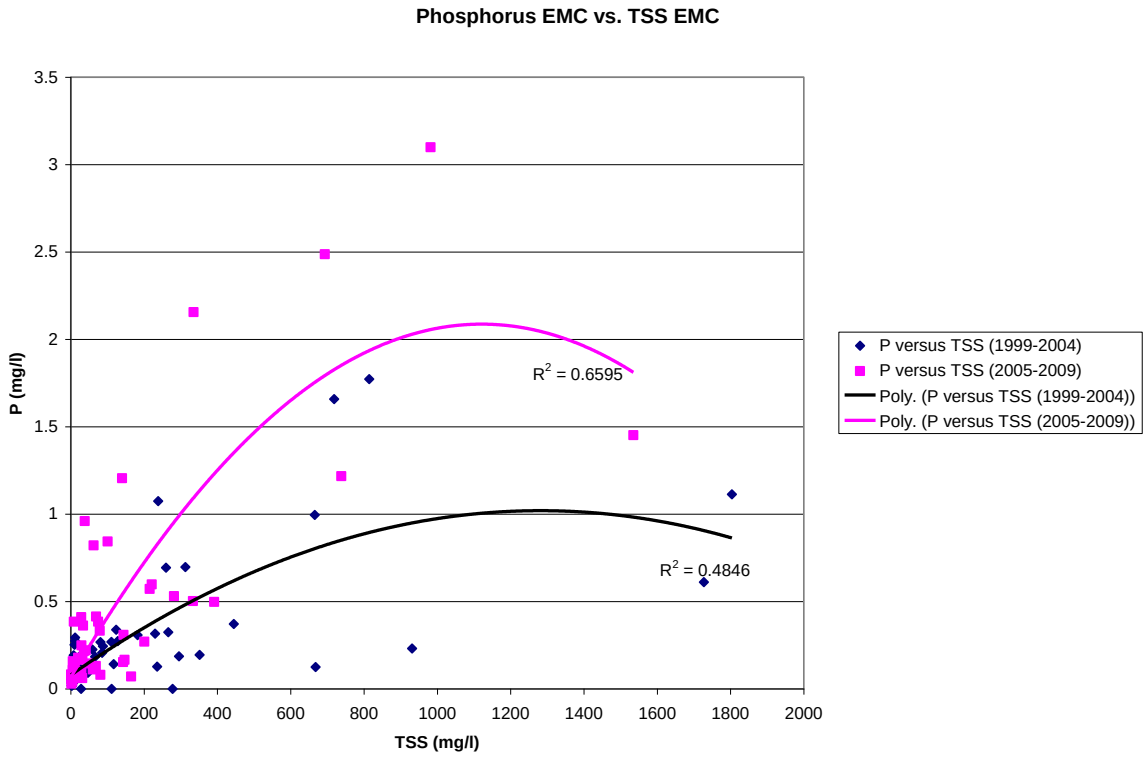

Figure 5-31. Relationship between storm event mean concentrations for phosphorus and TSS (May 1999 to September 2009) at the instream station.

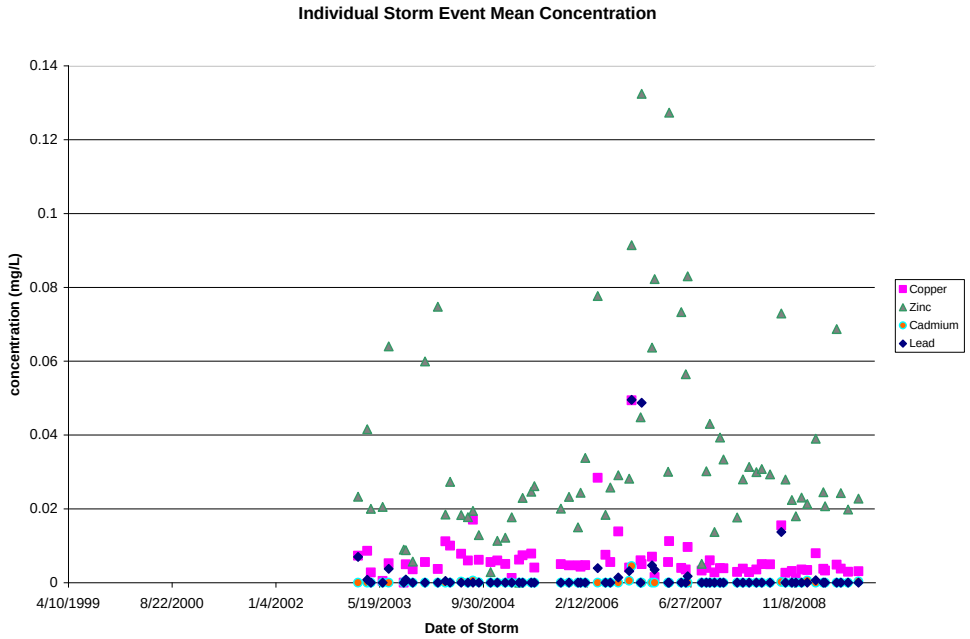

Figure 5-32. Storm event mean concentrations for metals (February 2004 to September 2009) at the outfall station. Values below detection limit are set to zero.

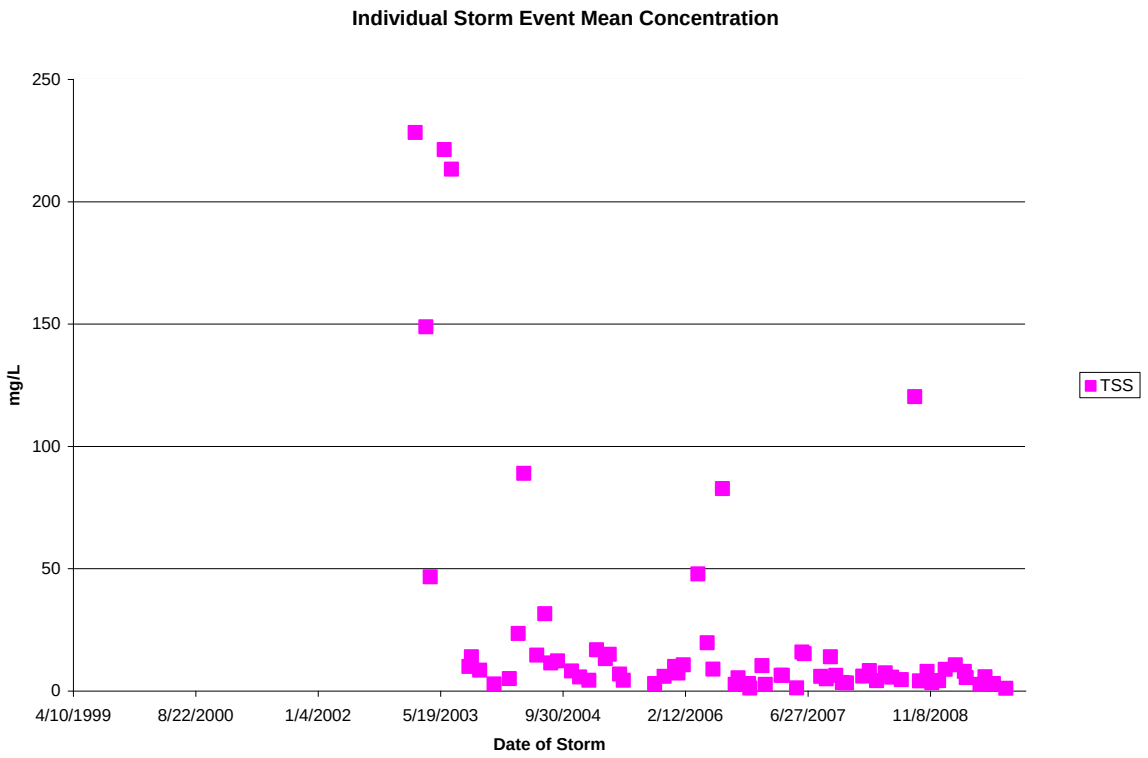

Figure 5-33. Storm event mean concentrations for TSS (May 1999 to September 2009) at the outfall station

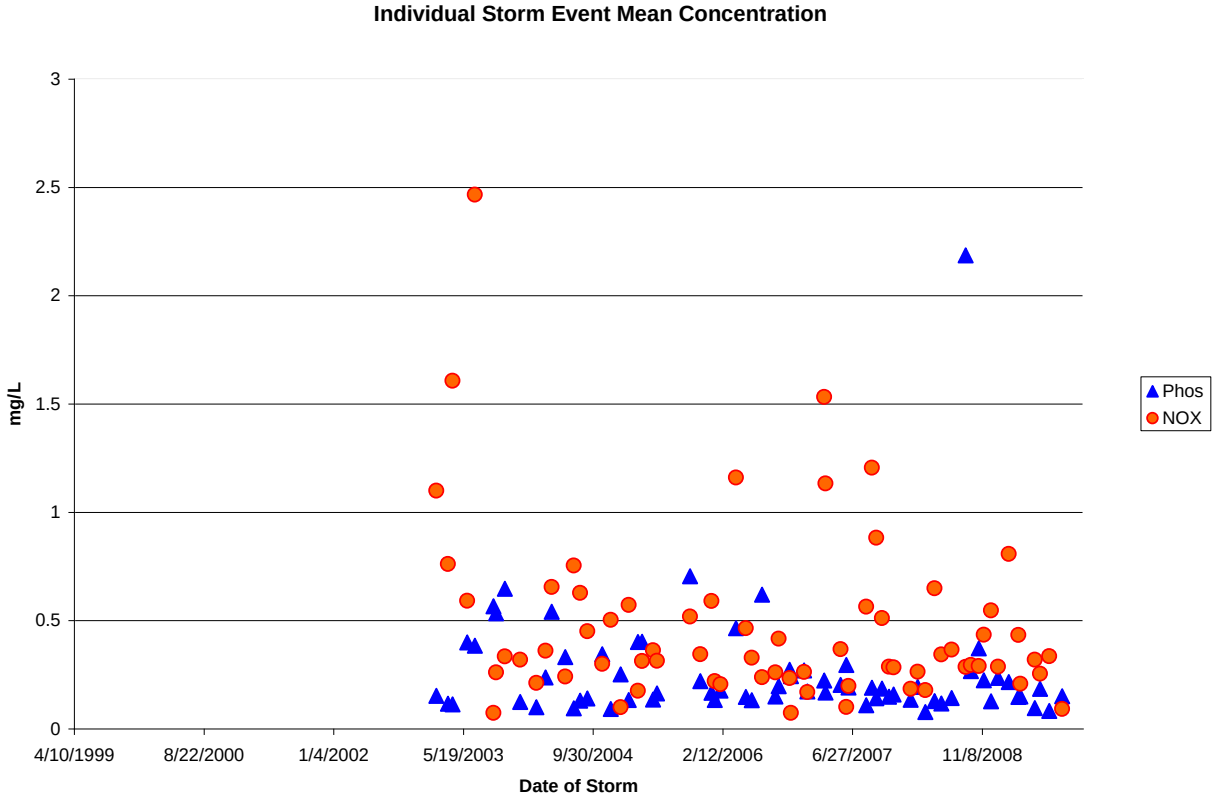

Figure 5-34. Storm event mean concentrations for phosphorus and nitrate + nitrite (May 1999 to September 2009) at the outfall station. Values below detection limit are set to zero.

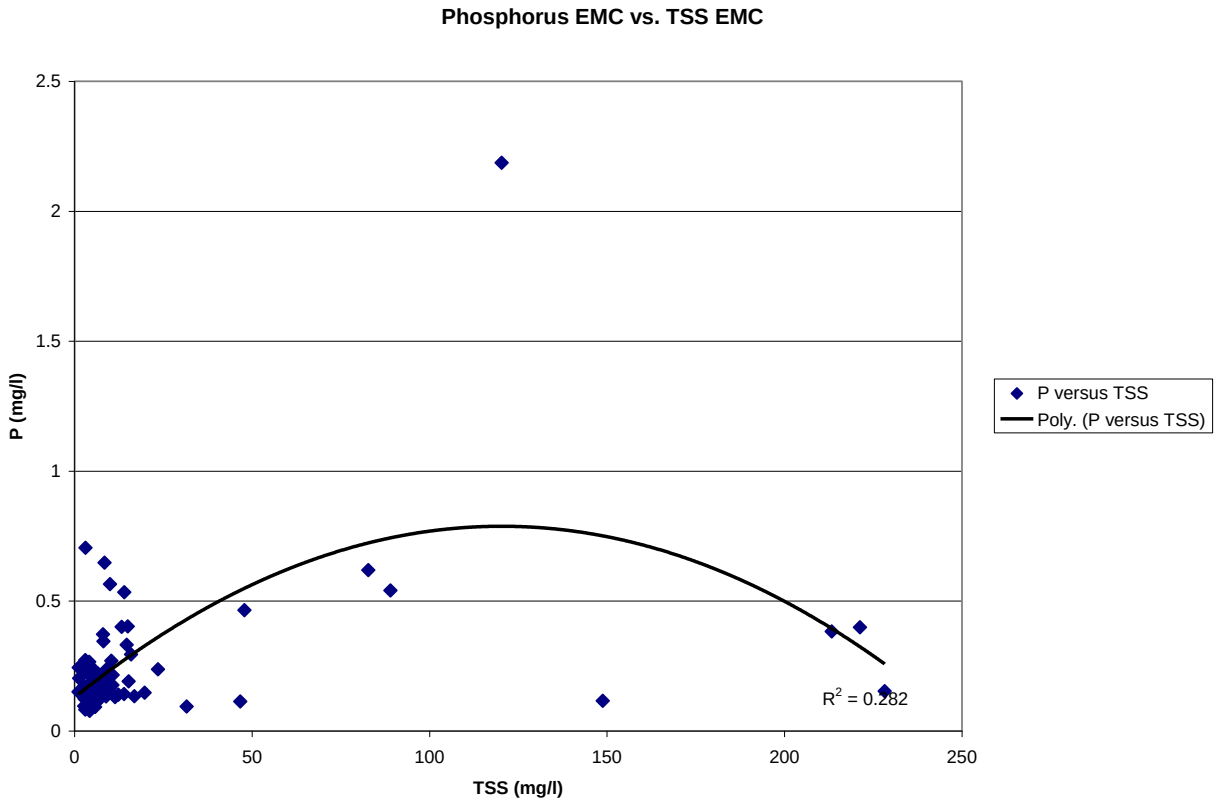

Figure 5-35. Relationship between storm event mean concentrations for phosphorus and TSS (May 1999 to September 2009) at the outfall station.

Physical changes within the stream channel, possibly a result of channel adjustment in response to an altered flow regime, were readily apparent. Changes in the stream channel observed include a temporary increase in deposition of fine sediments (most notably during the early period of most extensive land clearing), substantial bank erosion as measured using bank pins (Figure 5-23), changes in channel cross-section geometry (Figures 5-24 and 5-25), and field observations of channel bar formation and lateral channel migration.

5.1.4.3 Biological Indicators

This year, PPAN-01 was rated Fair again by the fish IBI, after rating being rated Good from 2005-2007 (Figure 5-36). The fish IBI also declined at PPAN-02 with a rating of Fair, after rating in the Good category in 2007. While the diversity of fish species was relatively high at all but the PPAN-04 station, most of the fish sampled were considered tolerant of disturbance. PPAN-04, which had shown minor improvement by rating Poor for three consecutive years, has returned to a rating of Very Poor in 2009 (Table F-5). Overall, scores for fish at all four stations have improved a category or remained stable compared to observations made in the study's initial years (1999-2001).

Benthic scores despite rating as Fair at two sites in 2008, were again all in the Poor or Very Poor categories for 2009. The benthic community appears to have been greatly affected by drought conditions in 2002, with scores not recovering to pre-drought levels until 2005. Another drought in 2007 may have been partly responsible for the low BIBI scores seen that year. 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. Direct infiltration is reduced and lower baseflows leave stream biota vulnerable to increased temperature, decreased dissolved oxygen levels and a decrease in available habitat.

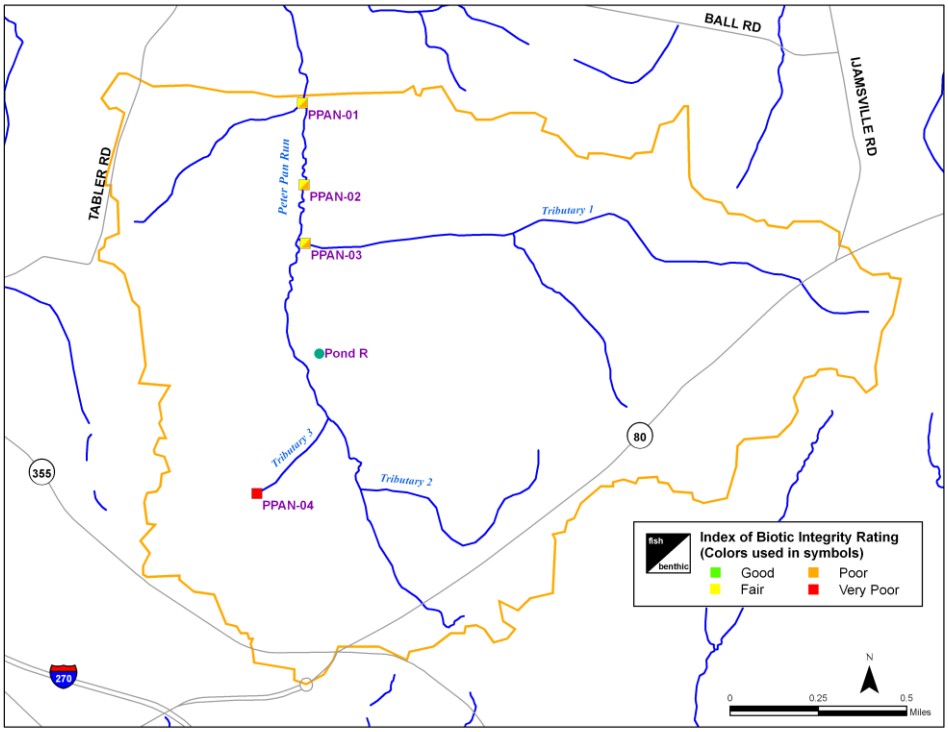

Figure 5-36. Index of Biological Integrity classes for Peter Pan Run monitoring in 2009.

Although fish IBI scores have shown some improvement in recent years, the continued depressed scores of the benthic community appear to reflect the noted changes in physical habitat, in particular the highly mobile substrate and bed features, which can make recolonization difficult. Fish, because they are more mobile and somewhat less dependent on bottom substrate for cover, are slightly more tolerant of frequent disturbances to the stream bed and depositional processes. However, the predominance of tolerant fish species shows that the overall fish community is still negatively impacted by the past and current agricultural and construction activities occurring in the Peter Pan Run watershed.

5.1.5 Plans for Future Long-Term Monitoring

As discussed in greater detail in Section 7.4, Frederick County has worked with its consultant Versar, Inc., and developed a three-pronged Stream Assessment and Monitoring (StreAM) program that will include:

1. the Frederick County Stream Survey (FCSS), a countywide probability-based survey using rapid benthic macroinvertebrate and physical habitat assessment methods to provide information on a finer scale than is currently available through the MBSS,
2. restoration monitoring to evaluate the success of individual restoration projects, customized to assess physical, biological, and/or water quality conditions, to determine if a restoration project meets design/performance criteria; and,
3. special studies to collect information that will support specific planning and management decisions at the County, including monitoring required by the NPDES permit.

Implementation of this new monitoring approach will affect various elements of the current monitoring effort, as indicated in Table 5-14.

Table 5-14. Summary of changes to Frederick County's long-term monitoring efforts

Monitoring Effort	Location	Plans
Storm Event Monitoring	Peter Pan Run: instream and outfall stations	No change to current monitoring procedures
Annual biological and physical monitoring in Peter Pan Run	4 stream stations in Peter Pan Run	No change to current monitoring procedures
Long-term monitoring at fixed watershed stations	Lower Bush Creek, Ballenger Creek, and Lower Linganore Creek	Has been replaced with the FCSS probability-based survey. Previously established sites are available for future monitoring if necessary
Watershed restoration project monitoring	Various locations within Lower Bush Creek, Ballenger Creek, Linganore Creek, and Bennett Creek	Continued pre- and post-restoration monitoring using methods tied to the projects' restoration goals