

**SUMMARY OF OPERATIONS AT THE  
HOLTWOOD DAM FISH PASSAGE FACILITY  
SPRING 2012**

October 2012

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Prepared for

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## EXECUTIVE SUMMARY

Fish lift operations began at the Conowingo East fish lift (EFL) on 2 April, 2012. The passage of over one-thousand American shad at the Conowingo EFL on 6 April triggered the start of fish lift operations at Holtwood on 7 April. This marks the earliest operation start date at the Holtwood fish passage facility. The Holtwood fish passage facility operated a total of 58 days (highest number of operating days in a single season since the facility became operational in 1997). The tailrace lift was operated on 47 consecutive days, while the spillway lift operated on 40 days. Lift operations were terminated for the season, with agency concurrence, on 5 June. During mid-May (17 and 18 May), fish lift operations were suspended for two days due to high river flows. The tailrace fish lift experienced crowder and hopper sheave mechanical problems (24 and 25 May) that could not be repaired prior to season end. After 25 May, the spillway fish lift operated solely until the season ended on 5 June. The 2012 fish passage season marks the sixteenth year of operation at Holtwood.

The lifts passed 230,365 fish of 26 taxa plus one hybrid. Gizzard shad (211,478), shorthead redhorse (4,679), quillback (4,568) and American shad (4,238), dominated the catch, and comprised nearly 98% of the total fish collected and passed. Walleye (2,354) and channel catfish (1,734) were also regularly observed in the daily catch. American shad represented the sole *Alosa* species collected and passed at Holtwood in 2012.

A total of 3,342 American shad (79% of total shad catch) was passed in the tailrace lift while the spillway lift accounted for 896 American shad (21% of total shad catch). The highest daily shad catch occurred on 19 April when 539 shad moved upstream during 10.8 hours of operation. On a daily basis, American shad passed through the fishway between 0700 hrs and 1959 hrs with 86% (3,651 of 4,238 shad) passed between 0900 and 1759 hrs.

Fishway operations were conducted at water temperatures ranging from 54.8°F to 79.0°F and river flows between 89,000 and 13,700 cfs (Figure 1). Spillage occurred on 42 days of operation. River water temperatures and river flows were within the observed historic range.

For most of the season, water clarity was moderately clear, making it possible to identify American shad with attached Maryland DNR floy tags if they passed by the viewing window. The number of floy tags observed at Holtwood in 2012 was 5 (4 orange, 1 pink).

The 2012 American shad passage rate at Holtwood versus Conowingo (19.1% of fish passing Conowingo passed Holtwood) was below the historical average of 31.0% (1997-2011).

A low, stable, river flow appears to be critical for enhancing American shad passage rates. In 2010, we documented 95% of American shad passed at river flows less than 40,000 cfs, with 5% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. In 2012, 76.9% of American shad passed at river flows less than 40,000 cfs, with 22.8% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. Only 0.3% of American shad passed at river flows greater than 60,000 cfs. Future operations of the fishway will build on the past sixteen years of operation experience.

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## **1.0 INTRODUCTION**

On 1 June 1993 representatives of PPL, two other upstream utilities, various state and federal resource agencies, and two sportsmen clubs signed the 1993 Susquehanna River Fish Passage Settlement Agreement. This agreement committed the Holtwood Hydroelectric Project (Holtwood) and the two other upstream hydroelectric projects to provide migratory fish passage at their facilities by the spring of 2000. A major element of this agreement was for PPL, the owner/operator of Holtwood, to construct and place a fishway into operation by 1 April 1997. PPL started construction on the fishway in April 1995, and met the spring 1997 operational target. The upstream passage facility consisting of a tailrace and spillway lift successfully operated during spring 1997 through spring 2012. This year marked the sixteenth operational season.

Objectives of 2012 upstream fishway operation were (1) monitor and maximize passage of migratory and resident fishes through the fishway; and (2) minimize interruptions to fish passage operations due to equipment breakdowns or malfunctions.

## **2.0 HOLTWOOD OPERATION**

### **2.1 Project Operation**

Holtwood, built in 1910, is situated on the Susquehanna River (river mile 24) in Lancaster and York counties, Pennsylvania (see figure in Normandeau Associates, Inc. 1998). It is the second upstream hydroelectric facility on the river. The project consists of a concrete gravity overflow dam 2,392 ft long by 55 ft high, a powerhouse with ten turbine units having a combined generating capacity of 107 MW, and a reservoir (Lake Aldred) of 2,400 acres surface area. Each unit is capable of passing approximately 3,000 cfs. Spills occur at the project when river flow or project inflow exceeds the station hydraulic capacity of approximately 31,500 cfs.

Hydraulic conditions in the spillway at the project are controlled by numerous factors that change hourly, daily and throughout the fishway operating season. The primary factors are river flows, operation of the power station, installation and integrity of the flash boards, and operation of the Safe Harbor Hydroelectric Station.

In spring 2012, all rubber dams were inoperable (not inflated) due to irreparable damage that occurred in previous years and current redevelopment activities. Wooden flashboards have been installed in place of these rubber dam sections. In spring of 2012, the flashboards closest to the Fish Lift facility were damaged and repairs could not be conducted until after cessation of fish lift operations due to consistent river flow and spill status. Operations began at the Holtwood Fish Lift facility on 7 April, after the passage of one-thousand shad at Conowingo Dam on 6 April. Since river flows were greater than station capacity, spill occurred on 42 of 58 days of fish lift operation, (Table 2). In 2012, station capacity was limited to a maximum of nine units due to maintenance on Unit 2 and various redevelopment activities. Passage operations ended on 5 June, with agency concurrence, due to river flows higher than station capacity, poor water clarity, increasing water temperatures, and the lack of American shad in the daily catch.

### **2.2 Fishway Design and Operation**

#### **2.2.1 Fishway Design**

The Holtwood fishway is sized to pass a design population of 2.7 million American shad and 10 million river herring. The design incorporates numerous criteria established by the USFWS and state resource agencies. Physical design parameters for the fishway are given in Normandeau Associates, Inc. (1998).

The fish passage facility at Holtwood is comprised of a tailrace and spillway lift (see figure in Normandeau Associates, Inc. 1998). The tailrace lift has two entrances (gates A and B) and the spillway lift has one entrance (gate C). Each lift has its own fish handling system that includes a mechanically operated crowder, picket screen(s), hopper, and hopper trough gate. Fishes captured in the lifts are sluiced into the trough through which the fish swim into Lake Aldred. Attraction flow, in, though, and from the lifts, is supplied via a piping system and five diffusers that are gravity fed from two trough intakes. Generally, water conveyance and attraction flow is controlled by regulating the three entrance gates and seven motor-operated valves. Fish that enter the tailrace and/or spillway entrances are attracted by water flow into the mechanically operated crowder chambers. Once inside, fish are crowded into the hoppers (6,700 gal capacity). Fish are then lifted in the hoppers and sluiced into the trough. Fish swim upstream through the trough past a counting facility and into the forebay through a 14 ft wide fish lift exit gate.

Design guidelines for fishway operation include five entrance combinations. These are: (1) entrances A, B, and C; (2) entrances A and B; (3) entrances A and C; (4) entrance A only; and (5) entrance C only. Completion of the attraction water system after the 1997 season resulted in the drafting of operating protocols and guidelines that are flexible and utilize experience gained during previous years of fish lift operation. In 2012, the following gate combinations were utilized: Entrances A and C (29 days); Entrance A only (18 days), and Entrance C only (11 days). . Entrance gate B was not used in 2012 due to rock and debris in the gate's channel guides. This problem will be addressed and Gate B should be operational in 2013. The spillway lift, (Entrance Gate C), has historically been used less frequently when river flows are greater than 40,000 cfs or flashboard sections are damaged or missing. However, with the completion of the Unit 1 draft tube extension that will supply attraction water to the Piney channel during fish lift operations, it is anticipated that Gate C will be used routinely to provide fish passage from the spillway area.

### **2.2.2 Fishway Operation**

Daily operation of the Holtwood fishway was based on the American shad catch, and managed to maximize that catch. Constant oversight by PPL and Normandeau staff ensured that maintenance activities and mechanical or electrical problems were dealt with immediately to minimize fish lift operational interruptions. Normal pre-season equipment preparations began in March 2012, as well as additional preparations (i.e. clearing mud out of diffusers and both hopper pits that was deposited during the fall flooding), and all equipment functioned properly at that time.

This year, Holtwood operations began one day after the passage of one-thousand American shad at Conowingo Dam. Fish lift operations began on 7 April. This year we recorded 58 days of operation. The tailrace lift was operated 47 days during this year's fish passage operation and encountered one major mechanical problem. On 24 May, the tailrace crowder cables snapped, so operations were modified to accommodate the cable problem. On 25 May, as the tailrace hopper was being raised during the third lift of the day, a grinding noise was noticed. The lift was completed and the problem reported. A crew was dispatched to investigate the problem. The crew attempted to lubricate the hopper and discovered that the downstream sheave bearing would not accept grease. It was determined that a bearing within the hopper sheave had frozen. Further investigations were conducted and the tailrace lift was shut down after it was determined that a new bearing would have to be ordered. The tailrace lift did not operate for the rest of the 2012 fish passage season. The spillway lift was operated on 40 days this season and encountered no major mechanical problems.

The 2012 American shad passage rate at Holtwood versus Conowingo (19.1% of fish passing Conowingo passed Holtwood) was below the historical average of 31.0% (1997-2011) (Table 6). Operational hours varied throughout the season in an attempt to maximize the catch of American shad.

Operation of the Holtwood fishway followed methods established during the 1997 and 1998 spring fish migration seasons. A three person staff consisting of a lift operator, a supervising biologist, and biological technician manned the facility daily. A detailed description of the fishway's major components and their operation are found in the 1997 and 1998 summary reports (Normandeau Associates, Inc. 1998 and 1999).

### **2.3 Fish Counts**

Fish passing the counting window are identified to species and counted by a biologist or biological technician. The counting area is located immediately downstream of the main attraction water supply area in the trough. As fish swim upstream and approach the counting area, they are directed by a series of fixed screens to swim up and through a 3 ft wide, 12 ft long channel on the west side of the trough. The channel is adjacent to a 4 ft by 10 ft window located in the counting room where fish are identified and counted. Passage from the fishway is controlled by two different gates. During the day, fish passage rates are controlled by the technician who opens/closes a set of gates downstream of the viewing window. At night fish are denied passage from the fishway by closing this gate. When necessary, flow is maintained through the exit channel to insure that adequate water quality exists for fish held overnight.

Fish passage data is handled by a single system that records and processes the data. The data (species and numbers passed) is recorded on a worksheet by the biologist or biological technician as fish pass the viewing window. At the end of each hour, fish passage data is entered into a Microsoft Excel spreadsheet and saved. Data processing and reporting is PC-based and accomplished by program scripts, or macros, created within Microsoft Excel spreadsheet software.

At day's end, the data is checked and verified by the biologist or biological technician. After data verification is completed, a daily summary of fish passage is produced and distributed to plant personnel. Each day's data is backed up to a diskette and stored off-site. Daily reports and weekly summaries of fish passage numbers are electronically distributed to members of the Holtwood FPTAC and other cooperators.

## **3.0 RESULTS**

### **3.1 Relative Abundance**

The diversity and abundance of fishes collected and passed in the Holtwood fishway during the spring 2012 operational period is presented in Table 1. A total of 230,365 fish of 26 taxa and one hybrid passed upstream into Lake Aldred. Gizzard shad (211,478), Shorthead redhorse (4,679), Quillback (4,568) and American shad (4,238), dominated the catch, and comprised nearly 98% of the total fish collected and passed. American shad represented the sole *Alosa* species collected and passed at Holtwood in 2012. The high passage day for all species combined occurred on 6 May, when 15,289 fish were passed, comprised mostly of gizzard shad (13,783), and shorthead redhorse (525).

For most of the season, water clarity ranged from 20 to 30 inches of visibility (Table 2), which made it possible for viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2012 was 5 (4 orange; 1 pink).

### **3.2 American Shad Passage**

A total of 4,238 American shad were passed at Holtwood during 2012; 3,342 American shad passed in the tailrace lift while the spillway lift accounted for 896 American shad (Table 3). The highest daily shad catch occurred on 19 April when 539 shad moved upstream during 10.8 hours of operation. Fishway operations were conducted at water temperatures ranging from 54.8°F to 79.0°F

and river flows between 89,000 and 13,700 cfs (as measured at Holtwood Dam), (Table 2 and Figure 1). Spillage occurred on 42 days of operation. River water temperatures and river flows were within the observed historic range.

The capture of shad at the fishway occurred over a relatively wide range of station operation and discharge conditions (Table 2). Shad were attracted to the tailrace lift at water elevations ranging from 115 ft. to 121 ft. Tailrace elevations correspond to unit operation, which varies from 0 to 10 units. In 2012, Unit 2 remained offline due to repairs and general maintenance. During spring 2012, tailrace fishway operation generally coincided with an eight turbine operation/generation scenario. Spillway lift operation usually occurs during periods of no or minimal spillage, but damaged flashboards and mechanical difficulties on the tailrace lift led to use of the spillway lift during spill events. Prior to fish lift operations in 2012, redevelopment activities included reshaping the Piney Island channel, installation of a weir in the Piney channel, and completion of the Unit 1 draft tube extension. Unit 1 was returned to operation in mid-May and operated during the remaining part of the season. Observations made by the biologists on site suggest an increase of resident fish collected and passed by the spillway lift, even during times of spill. The redesigned Piney channel and weir and operation of Unit 1 may be a positive factor for improving anadromous and resident fish passage in future years at Holtwood.

Passage of shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 164.5 ft to 174 ft (Table 2). We experienced some higher forebay levels this year due to the installation of higher flashboards (6 ft high) along the eastern section of the spillway. These boards were installed to protect a portion of the work and equipment related to the Redevelopment in the Piney channel. Forebay elevations during passage operations ranged from 166 ft to 170 ft for approximately 46% of the 2012 season.

The hourly passage numbers of American shad at Holtwood are provided in Table 4. On a daily basis, American shad passed through the fishway between 0700 hrs and 1959 hrs with 86% (3,651 of 4,238 shad) passed between 0900 and 1759 hrs. American shad passage was low each day of operation (<600 per day), and no strong patterns relating to passage time were determined.

Each year, we attempt to qualitatively assess the relative number of shad using the tailrace and spillway lifts by viewing each hopper of fish and estimating the number of shad in each lift as they are sluiced into the trough. The spillway lift was operated on forty days in an effort to pass any shad attracted into the spillway area adjacent to the fishlift. We summarized this information by lift, and applied results to the daily shad passage count. We determined the number of shad captured by each lift and/or the percentage of daily passage that was attributable to each lift. Based on this assessment, 3,342 and 896 shad were captured in the tailrace and spillway lifts over the total operating period in 2012, respectively (Table 3).

### **3.3 Passage Evaluation**

In spring 2012, our fishway evaluation efforts focused on maximizing the passage of American shad at both the tailrace and spillway lifts with minimal interruptions to passage operations due to equipment breakdowns or malfunctions.

We present a summary of American shad passage at three river flow ranges in Table 5. As stated in previous reports, low, stable river flows are more conducive to fish passage at Holtwood. In 2012, spill events occurred during 42 of 58 days of fishway operation. In 2010, we documented 95% of American shad passed at river flows less than 40,000 cfs, with 5% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. In 2012, 76.9% of American shad passed at river flows less than 40,000cfs, with 22.8% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. Only 0.3% of American shad passed at river flows greater than 60,000cfs (Table 5 and Figure 2). During

fish lift operations in 2012, river flows ranged from 89,000 and 13,700 cfs. The 2012 American shad passage rate at Holtwood versus Conowingo (19.1% of American shad passed at Conowingo were passed by Holtwood), was below the historical average of 31.0% observed at Holtwood from 1997 to 2011 (Table 6).

We hope to optimize future fishway operations by utilizing knowledge gained through these sixteen years of operation. Debugging of the fishway occurred as needed throughout the season, and operation was modified based on conditions encountered on a daily basis. Fish survival in the fishways was excellent; we observed 0 shad mortalities during the 2012 American shad passage season.

#### **4.0 RECOMMENDATIONS**

- 1) Review the current maintenance program to identify additional equipment maintenance inspection and testing activities to reduce in-season disruptions to operation. Unusual conditions, (e.g. severe flood events) require a more thorough review of the impacts to the equipment.
- 2) Operate the fishway at Holtwood Dam under annual operational guidelines developed and approved by the HFPTAC. Fishway operation should adhere to these guidelines; however, personnel must retain the ability to make “on-the-spot” modifications to maximize fishway performance.
- 3) Continue, as a routine part of fishway operation, a maintenance program that includes periodic scheduled drawdowns and cleaning of the exit channel as necessary, nightly inspections of picket screens, and daily checks of hopper doors. Routine maintenance activities minimize disruption of fishway operation.
- 4) Implement protocols/guidelines to spill trash through gates 7 and 9. This should be done on an as needed basis prior to or after daily scheduled fishway operations.

#### **5.0 LITERATURE CITED**

- Normandeau Associates, Inc. 1998. Summary of operation at the Holtwood Fish Passage Facility in 1997. Report prepared for PPL, Inc., Allentown, PA.
- Normandeau Associates, Inc. 1999. Summary of the operation at the Holtwood Fish Passage Facility in 1998. Report prepared for PPL, Inc., Allentown, PA.

## **TABLES AND FIGURES**

**Table 1****Summary of the daily number of fish passed by the Holtwood fish passage facility in 2012.**

<i>Date:</i>	<i>7 Apr</i>	<i>8 Apr</i>	<i>9 Apr</i>	<i>10 Apr</i>	<i>11 Apr</i>	<i>12 Apr</i>	<i>13 Apr</i>	<i>14 Apr</i>	<i>15 Apr</i>	<i>16 Apr</i>
<i>Hours of Operation - Tailrace:</i>	9.8	6.7	2.7	5.0	10.6	9.8	10.2	10.0	9.1	10.4
<i>Number of Lifts - Tailrace:</i>	12	13	5	8	17	17	17	15	15	18
<i>Hours of Operation - Spillway:</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Number of Lifts - Spillway:</i>	0	0	0	0	0	0	0	0	0	0
<i>Water Temperature (*F):</i>	56.3	56.8	56.3	56.8	55.4	54.7	54.4	54.5	54.8	56.0
American shad	93	44	11	29	17	6	3	1	3	151
Gizzard shad	447	571	628	840	838	1,073	334	58	1,122	871
Sea lamprey	0	0	0	0	0	0	0	0	0	0
Rainbow trout	0	0	0	0	0	0	0	0	0	0
Brown trout	3	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0
Carp	1	0	0	0	0	1	0	1	15	0
Quillback	1	1	0	1	1	0	0	0	0	0
Shorthead redhorse	50	76	2	12	9	8	0	10	3	24
Channel catfish	3	23	0	1	0	0	0	0	1	0
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0	0	0	0	0	0	0	0	0	0
White sucker	0	0	0	0	0	0	0	0	5	0
Nothern Hog sucker	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0	0	0
Bluegill	0	1	0	0	0	0	0	0	0	0
Smallmouth bass	37	13	4	3	12	2	0	6	3	3
Largemouth bass	0	0	0	0	0	0	0	0	0	3
Black crappie	0	0	0	0	0	0	0	0	0	1
White crappie	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0	0	0
Walleye	36	47	9	9	15	15	0	11	3	3
Striped Bass	0	0	0	0	0	0	0	0	0	0
Hybrid Striped Bass	0	0	0	0	0	0	0	0	0	0
Comely Shiner	0	0	0	0	0	0	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>671</b>	<b>776</b>	<b>654</b>	<b>895</b>	<b>892</b>	<b>1,105</b>	<b>337</b>	<b>87</b>	<b>1,155</b>	<b>1,056</b>

**Table 1****Continued.**

<i>Date:</i>	<i>17 Apr</i>	<i>18 Apr</i>	<i>19 Apr</i>	<i>20 Apr</i>	<i>21 Apr</i>	<i>22 Apr</i>	<i>23 Apr</i>	<i>24 Apr</i>	<i>25 Apr</i>	<i>26 Apr</i>
<i>Hours of Operation - Tailrace:</i>	11.0	10.3	10.8	10.4	10.7	10.5	10.5	10.4	10.9	10.3
<i>Number of Lifts - Tailrace:</i>	20	19	18	18	17	18	17	17	17	12
<i>Hours of Operation - Spillway:</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	10.2
<i>Number of Lifts - Spillway:</i>	0	0	0	0	0	0	0	0	8	11
<i>Water Temperature (*F):</i>	58.8	59.3	60.8	61.7	64.3	64.6	62.8	61.4	60.4	60.2
American shad	244	231	539	329	436	233	53	87	127	6
Gizzard shad	1,991	9,589	10,022	4,772	3,648	3,810	3,538	1,646	2,966	845
Sea lamprey	0	1	0	0	0	1	0	0	1	0
Rainbow trout	1	0	0	0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0	0	0	1	0
Muskellunge	0	0	0	0	1	0	0	0	0	0
Carp	4	0	2	0	0	0	1	0	3	2
Quillback	69	7	15	56	151	152	70	96	68	14
Shorthead redhorse	379	59	38	121	305	112	28	93	15	24
Channel catfish	4	5	1	0	4	11	7	32	33	57
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0	0	0	0	0	0	0	0	0	0
White sucker	0	0	0	0	0	0	0	0	0	0
Northern Hog sucker	0	0	0	0	0	0	0	1	0	0
Rock bass	0	0	0	0	1	0	0	1	0	0
Pumpkinseed	0	0	0	0	0	0	0	0	0	0
Bluegill	0	0	0	0	0	0	0	0	0	0
Smallmouth bass	20	6	4	17	22	12	1	1	10	2
Largemouth bass	5	3	0	2	6	0	0	1	5	1
Black crappie	0	0	0	1	0	0	0	0	1	0
White crappie	0	1	0	1	0	0	0	1	0	0
Yellow perch	0	0	0	0	0	0	0	0	0	0
Walleye	25	24	34	47	66	55	34	11	42	75
Striped Bass	1	0	0	0	0	0	0	0	0	0
Hybrid Striped Bass	0	0	0	0	0	0	0	0	0	0
Comely Shiner	0	0	0	0	0	0	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>2,743</b>	<b>9,926</b>	<b>10,655</b>	<b>5,346</b>	<b>4,640</b>	<b>4,386</b>	<b>3,732</b>	<b>1,970</b>	<b>3,272</b>	<b>1,026</b>

**Table 1****Continued.**

<i>Date:</i>	<i>27 Apr</i>	<i>28 Apr</i>	<i>29 Apr</i>	<i>30 Apr</i>	<i>1 May</i>	<i>2 May</i>	<i>3 May</i>	<i>4 May</i>	<i>5 May</i>	<i>6 May</i>
<i>Hours of Operation - Tailrace:</i>	10.5	10.1	9.9	10.3	9.7	9.4	8.1	10.5	10.0	9.8
<i>Number of Lifts - Tailrace:</i>	12	11	13	12	12	12	12	17	16	16
<i>Hours of Operation - Spillway:</i>	10.3	10.2	9.8	10.1	9.7	9.9	10.2	10.6	9.9	9.3
<i>Number of Lifts - Spillway:</i>	9	8	10	9	11	10	16	16	14	12
<i>Water Temperature (*F):</i>	56.1	56.1	55.8	55.5	54.8	56.2	57.2	60.5	62.6	65.1
American shad	0	2	3	1	2	0	33	246	276	157
Gizzard shad	191	151	192	197	206	240	2,576	12,131	13,523	13,783
Sea lamprey	0	0	0	0	0	0	0	0	0	1
Rainbow trout	0	0	0	0	0	0	0	0	0	0
Brown trout	0	1	1	1	1	0	0	0	0	3
Muskellunge	0	1	0	0	0	0	1	0	0	0
Carp	0	5	6	2	2	6	2	4	9	30
Quillback	5	10	80	25	4	75	1,327	788	243	475
Shorthead redhorse	74	49	104	56	29	98	645	352	174	525
Channel catfish	29	21	29	6	8	21	0	0	7	96
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0	0	0	0	0	0	0	0	0	0
White sucker	0	0	0	0	0	0	0	0	0	0
Northern Hog sucker	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	0	0	0	0	1
Pumpkinseed	0	0	0	0	0	0	0	0	0	1
Bluegill	0	0	0	0	0	0	0	1	1	0
Smallmouth bass	7	3	8	1	4	4	21	24	37	46
Largemouth bass	2	0	1	0	0	0	3	5	7	0
Black crappie	0	0	0	0	0	0	0	0	0	0
White crappie	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0	0	0
Walleye	28	21	22	20	38	43	12	59	58	170
Striped Bass	0	0	0	0	0	0	0	0	0	0
Hybrid Striped Bass	0	0	0	0	0	0	0	0	1	1
Comely Shiner	0	0	0	0	0	58	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>336</b>	<b>264</b>	<b>446</b>	<b>309</b>	<b>294</b>	<b>545</b>	<b>4,620</b>	<b>13,610</b>	<b>14,336</b>	<b>15,289</b>

**Table 1****Continued.**

<i>Date:</i>	<i>7 May</i>	<i>8 May</i>	<i>9 May</i>	<i>10 May</i>	<i>11 May</i>	<i>12 May</i>	<i>13 May</i>	<i>14 May</i>	<i>15 May</i>	<i>16 May</i>
<i>Hours of Operation - Tailrace:</i>	11.6	9.7	9.9	8.0	8.0	8.0	8.1	8.2	9.1	3.3
<i>Number of Lifts - Tailrace:</i>	16	15	16	10	11	11	12	12	14	5
<i>Hours of Operation - Spillway:</i>	9.0	9.0	9.7	8.1	8.1	8.1	8.2	8.1	9.2	3.4
<i>Number of Lifts - Spillway:</i>	10	10	14	8	9	9	9	10	13	5
<i>Water Temperature (*F):</i>	68.1	65.9	64.2	64.2	63.2	62.4	62.5	64.4	65.4	65.3
American shad	133	79	87	5	0	1	1	4	65	8
Gizzard shad	10,265	9,632	14,713	5,852	5,577	7,940	3,875	4,374	14,751	889
Sea lamprey	0	0	0	0	0	0	0	1	0	0
Rainbow trout	1	0	0	0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	2	0	0	0	0
Muskellunge	0	0	1	0	0	0	0	0	0	0
Carp	5	10	10	5	1	2	1	6	4	1
Quillback	236	99	35	5	9	2	4	29	16	0
Shorthead redhorse	184	180	93	22	29	19	23	28	23	1
Channel catfish	11	11	35	0	10	21	37	13	9	20
Flathead catfish	2	0	0	0	0	0	0	0	0	0
Brown Bullhead	0	0	2	0	0	0	0	0	0	0
White sucker	0	0	0	0	0	0	0	0	0	0
Northern Hog sucker	0	0	0	0	0	0	0	0	0	0
Rock bass	1	0	2	0	0	1	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0	0	0
Bluegill	0	1	3	0	0	2	1	0	0	0
Smallmouth bass	39	30	8	3	3	4	1	4	4	0
Largemouth bass	2	0	0	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0	0	0
White crappie	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	3	0	0	0	0	0	0	1
Walleye	46	143	94	61	34	27	46	67	113	4
Striped Bass	0	0	1	0	0	0	0	0	0	0
Hybrid Striped Bass	0	0	0	0	0	0	0	0	0	0
Comely Shiner	0	0	184	0	0	0	0	0	0	0
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>10,925</b>	<b>10,185</b>	<b>15,271</b>	<b>5,953</b>	<b>5,663</b>	<b>8,021</b>	<b>3,989</b>	<b>4,526</b>	<b>14,985</b>	<b>924</b>

**Table 1****Continued.**

<i>Date:</i>	<i>17 May</i>	<i>18 May</i>	<i>19 May</i>	<i>20 May</i>	<i>21 May</i>	<i>22 May</i>	<i>23 May</i>	<i>24 May</i>	<i>25 May</i>	<i>26 May</i>
<i>Hours of Operation - Tailrace:</i>	*	*	8.0	8.0	7.9	8.7	8.6	9.0	5.7	0.0
<i>Number of Lifts - Tailrace:</i>			13	12	12	14	14	11	4	0
<i>Hours of Operation - Spillway:</i>			7.7	8.1	7.8	8.2	8.7	8.9	9.0	9.6
<i>Number of Lifts - Spillway:</i>			8	9	9	9	9	13	14	19
<i>Water Temperature (*F):</i>			65.9	66.0	68.3	69.1	69.1	69.9	71.2	72.5
American shad			2	4	13	37	30	96	17	98
Gizzard shad			4,071	2,516	4,017	6,420	5,313	5,868	3,423	3,790
Sea lamprey			0	0	0	0	0	0	0	0
Rainbow trout			0	1	0	0	0	3	0	1
Brown trout			0	0	0	2	3	0	2	0
Muskellunge			0	1	1	0	1	0	0	0
Carp			0	1	1	7	3	3	7	21
Quillback			0	0	2	17	23	43	40	105
Shorthead redhorse			0	6	3	72	53	54	71	178
Channel catfish			7	16	18	22	41	39	146	209
Flathead catfish			3	1	0	1	1	1	0	0
Brown Bullhead			0	0	0	0	0	0	0	0
White sucker			0	0	0	0	0	0	0	0
Northern Hog sucker			0	0	0	0	0	0	0	0
Rock bass			1	0	0	0	1	0	0	0
Pumpkinseed			0	0	0	0	0	0	0	0
Bluegill			1	1	0	1	6	0	0	0
Smallmouth bass			0	0	1	3	3	6	1	4
Largemouth bass			0	0	0	0	1	0	0	1
Black crappie			0	0	0	0	0	0	0	0
White crappie			0	0	0	0	0	0	0	0
Yellow perch			0	0	0	0	0	0	0	0
Walleye			2	5	9	41	33	97	90	142
Striped Bass			0	0	0	0	0	0	0	0
Hybrid Striped Bass			0	0	0	0	0	0	0	0
Comely Shiner			0	0	0	0	0	0	0	95
Spotfin Shiner			0	0	0	0	0	0	0	0
<b>Total</b>	<b>0</b>	<b>0</b>	<b>4,087</b>	<b>2,552</b>	<b>4,065</b>	<b>6,623</b>	<b>5,512</b>	<b>6,210</b>	<b>3,797</b>	<b>4,644</b>

**Table 1****Continued.**

<i>Date:</i>	<i>27 May</i>	<i>28 May</i>	<i>29 May</i>	<i>30 May</i>	<i>31 May</i>	<i>1 Jun</i>	<i>2 Jun</i>	<i>3 Jun</i>	<i>4 Jun</i>	<i>5 Jun</i>	<i>TOTAL</i>
<i>Hours of Operation - Tailrace:</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<b>322.6</b>
<i>Number of Lifts - Tailrace:</i>	0	0	0	0	0	0	0	0	0	0	<b>469.0</b>
<i>Hours of Operation - Spillway:</i>	8.9	8.0	8.0	8.0	8.3	8.0	5.8	5.0	4.9	5.3	<b>337.8</b>
<i>Number of Lifts - Spillway:</i>	15	14	12	14	10	11	9	7	7	7	<b>427.0</b>
<i>Water Temperature (*F):</i>	74.0	75.5	77.7	79.4	78.5	77.6	75.5	71.3	69.9	68.5	
American shad	88	99	0	7	1	0	0	0	0	0	<b>4,238</b>
Gizzard shad	2,102	1,803	82	1,205	83	78	10	9	9	12	<b>211,478</b>
Sea lamprey	0	0	0	0	0	0	0	0	0	0	<b>5</b>
Rainbow trout	0	0	0	0	0	0	0	0	0	0	<b>7</b>
Brown trout	2	2	0	0	0	0	0	0	0	0	<b>24</b>
Muskellunge	2	0	0	1	0	0	0	0	0	0	<b>10</b>
Carp	0	20	0	6	0	0	0	0	0	0	<b>210</b>
Quillback	37	55	0	77	0	0	0	0	0	0	<b>4,568</b>
Shorthead redhorse	85	62	2	16	1	0	0	0	0	0	<b>4,679</b>
Channel catfish	125	195	53	208	14	31	36	4	2	2	<b>1,734</b>
Flathead catfish	0	0	0	1	0	0	3	0	0	0	<b>13</b>
Brown Bullhead	0	0	0	0	0	0	0	0	0	0	<b>2</b>
White sucker	0	0	0	0	0	0	0	0	0	0	<b>5</b>
Northern Hog sucker	0	0	0	0	0	0	0	0	0	0	<b>1</b>
Rock bass	0	0	0	0	0	0	0	0	0	0	<b>9</b>
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	<b>1</b>
Bluegill	0	0	0	0	0	0	0	0	0	0	<b>19</b>
Smallmouth bass	7	2	0	0	1	0	0	0	0	0	<b>457</b>
Largemouth bass	0	0	0	0	0	0	0	0	0	0	<b>48</b>
Black crappie	0	0	0	0	0	0	0	0	0	0	<b>3</b>
White crappie	1	0	0	0	0	0	0	0	0	0	<b>4</b>
Yellow perch	0	0	0	0	0	0	0	0	0	0	<b>4</b>
Walleye	129	98	8	31	2	0	0	0	0	0	<b>2,354</b>
Striped Bass	0	0	0	0	0	0	0	0	0	0	<b>2</b>
Hybrid Striped Bass	0	0	0	0	0	0	0	0	0	0	<b>2</b>
Comely Shiner	0	90	0	25	0	0	0	11	0	0	<b>463</b>
Spotfin Shiner	20	0	0	0	0	5	0	0	0	0	<b>25</b>
<b>Total</b>	<b>2,598</b>	<b>2,426</b>	<b>145</b>	<b>1,577</b>	<b>102</b>	<b>114</b>	<b>49</b>	<b>24</b>	<b>11</b>	<b>14</b>	<b>230,365</b>

**Table 2**

**Summary of daily average river flow, water temperature, unit operation, fishway weir gate operation, and project water elevations during operation of the Holtwood fish passage facility in 2012.**

Date	River Flow (cfs)	Ave. Water Temp. (°F)	Secchi (in)	Number of Units	Weir Gate Operation			Elevation (ft)		
					A	B	C*	Tailrace	Spillway	Forebay
7 Apr	22,900	56.64	30	8	X			115	115	169
8 Apr	23,200	56.84	28	8	X			121	Spill	170
9 Apr	21,000	56.76	28	8	X			117	Spill	169
10 Apr	19,100	56.48	28	8	X			116.5	Spill	170
11 Apr	19,000	55.59	28	8	X			117	115	167
12 Apr	18,400	55.05	28	8	X			117	115	167
13 Apr	16,100	54.93	28	8	X			117.5	115	165
14 Apr	17,100	54.86	24	8	X			121	115	165
15 Apr	16,000	55.37	24	8	X			118	115	164.5
16 Apr	16,100	56.52	24	8	X			113	Spill	167
17 Apr	15,500	59.25	24	6	X			116	115	166
18 Apr	14,900	60.08	24	4	X			116	115	166.5
19 Apr	14,300	62.31	26	8	X			116	115	166.4
20 Apr	16,900	63.14	26	8	X			117	115	167
21 Apr	13,700	64.55	26	8	X			113	115	166
22 Apr	14,800	64.40	26	8	X			106	115	167
23 Apr	18,500	62.54	26	8	X			118.5	115	167
24 Apr	18,000	61.60	26	8	X			118.5	115	167.5
25 Apr	23,400	61.23	26	8	X		X	119	115	169
26 Apr	35,200	58.97	18	8	X		X	119.3	Spill	169.4
27 Apr	43,500	56.12	22	8	X		X	121	Spill	171.5
28 Apr	41,200	55.91	22	8	X		X	120	Spill	172
29 Apr	39,200	55.81	22	8	X		X	120	Spill	172
30 Apr	37,300	55.50	18	7	X		X	120.5	Spill	172
1 May	33,600	55.46	18	8	X		X	121	Spill	171
2 May	31,400	56.49	20	8	X		X	121	Spill	171.5

**Table 2**

**Continued.**

Date	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Number of Units	Weir Gate Operation			Elevation (ft)		
					A	B	C	Tailrace	Spillway	Forebay
3 May	30,700	58.02	30	9	X		X	120	Spill	169
4 May	29,400	60.85	31	9	X		X	119	Spill	169
5 May	41,300	63.27	32	9	X		X	119.3	Spill	168
6 May	46,400	65.76	33	9	X		X	121	Spill	172
7 May	50,200	67.60	32	9	X		X	120	Spill	173
8 May	46,300	65.45	30	9	X		X	121	Spill	171
9 May	45,600	64.30	30-24	9	X		X	119.5	Spill	171
10 May	56,700	64.33	26	9	X		X	121	Spill	173
11 May	65,200	63.57	20	9	X		X	121	Spill	173
12 May	64,500	62.94	20	9	X		X	121	Spill	173
13 May	56,800	63.46	20	9	X		X	121	Spill	172
14 May	49,100	64.78	22	9	X		X	121.3	Spill	172
15 May	51,500	65.44	22	9	X		X	119.5	Spill	171.5
16 May	89,000	65.74	20	8	X		X	120	Spill	174
17 May	107,300	66.14	--	--	--	--	--	--	--	--
18 May	90,200	65.49	--	--	--	--	--	--	--	--
19 May	70,800	65.95	18	8	X		X	120	Spill	172.3
20 May	57,100	66.96	18	8	X		X	120	Spill	172
21 May	47,500	68.45	22	8	X		X	120	Spill	172
22 May	41,700	69.11	24	8	X		X	119	Spill	170
23 May	39,800	69.2	24	8	X		X	119.5	Spill	170
24 May	40,400	69.93	24	6	X		X	116.5	Spill	170
25 May	39,100	71.36	20	6	X		X	117	Spill	171
26 May	34,800	72.71	21-18	8			X	117	Spill	168
27 May	31,800	74.36	21-18	8			X	119	Leakage	168
28 May	39,400	76.36	21-18	8			X	119	Spill	169
29 May	46,900	78.16	20	8			X	119.4	Spill	171
30 May	44,300	79.03	18-10	8			X	118	Spill	168.3
31 May	46,900	78.33	18-12	6			X	116.4	Spill	171
1 Jun	46,500	77.04	16	8			X	116	Spill	171
2 Jun	53,600	74.36	10-4	8			X	118	Spill	172
3 Jun	64,400	71.42	2	8			X	120.9	Spill	172
4 Jun	56,300	69.8	2	8			X	119.5	Spill	172
5 Jun	50,700	68.4	5	8			X	119.3	Spill	170.5

Table 3

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2012.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
7-Apr	93	93	--	100%	--
8-Apr	44	44	--	100%	--
9-Apr	11	11	--	100%	--
10-Apr	29	29	--	100%	--
11-Apr	17	17	--	100%	--
12-Apr	6	6	--	100%	--
13-Apr	3	3	--	100%	--
14-Apr	1	1	--	100%	--
15-Apr	3	3	--	100%	--
16-Apr	151	151	--	100%	--
17-Apr	244	244	--	100%	--
18-Apr	231	231	--	100%	--
19-Apr	539	539	--	100%	--
20-Apr	329	329	--	100%	--
21-Apr	436	436	--	100%	--
22-Apr	233	233	--	100%	--
23-Apr	53	53	--	100%	--
24-Apr	87	87	--	100%	--
25-Apr	127	127	0	100%	0%
26-Apr	6	6	0	100%	0%
27-Apr	0	0	0	0%	0%
28-Apr	2	1	1	50%	50%
29-Apr	3	3	0	100%	0%
30-Apr	1	1	0	100%	0%
1-May	2	1	1	50%	50%
2-May	0	0	0	0%	0%
3-May	33	10	23	30%	70%
4-May	246	74	172	30%	70%
5-May	276	152	124	55%	45%
6-May	157	125	32	80%	20
7-May	133	113	20	85%	15%
8-May	79	49	30	62%	38%
9-May	87	27	60	30%	70%
10-May	5	3	2	60%	40%
11-May	0	0	0	0%	0%
12-May	1	1	0	100%	0%
13-May	1	1	0	100%	0%
14-May	4	4	0	100%	0%
15-May	65	13	52	20%	80%
16-May	8	8	0	100%	0%
17-May	*	--	--	--	--
18-May	*	--	--	--	--
19-May	2	2	0	100%	0%
20-May	4	2	2	50%	50%
21-May	13	13	0	100%	0%
22-May	37	37	0	100%	0%
23-May	30	28	2	94%	6%
24-May	96	29	67	30%	70%
25-May	17	2	15	12%	88%
26-May	98	**	98	--	100%
27-May	88	--	88	--	100%
28-May	99	--	99	--	100%
29-May	0	--	0	--	0%
30-May	7	--	7	--	100%
31-May	1	--	1	--	100%
1-Jun	0	--	0	--	0%
2-Jun	0	--	0	--	0%
3-Jun	0	--	0	--	0%
4-Jun	0	--	0	--	0%
5-Jun	0	--	0	--	0%
<b>Total</b>	<b>4,238</b>	<b>3,342</b>	<b>896</b>	<b>79%</b>	<b>21%</b>

\* Shut Down due to High Flow Event

\*\* Tailrace Lift shut down for rest of season due to tailrace crowder and hopper sheave mechanical problems

**Table 4**

**Hourly summary of American shad passage at the Holtwood fish passage facility in 2012.**

<i>Date:</i>	<i>7 Apr</i>	<i>8 Apr</i>	<i>9 Apr</i>	<i>10 Apr</i>	<i>11 Apr</i>	<i>12 Apr</i>	<i>13 Apr</i>
<i>Observation Time (Start):</i>	8:50	12:25	8:43	14:20	8:10	8:50	8:30
<i>Observation Time (End):</i>	18:35	19:00	12:00	19:00	19:00	18:59	18:50
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	6	--	2	--	1	1	--
0900 to 0959	5	--	5	--	1	--	--
1000 to 1059	--	--	3	--	2	1	--
1100 to 1159	12	--	1	--	2	--	--
1200 to 1259	14	13	0	--	0	--	2
1300 to 1359	9	11	0	--	1	--	--
1400 to 1459	2	4	0	6	2	1	--
1500 to 1559	12	8	--	8	6	--	1
1600 to 1659	16	--	--	7	1	1	--
1700 to 1759	13	2	--	3	0	--	--
1800 to 1859	4	6	--	5	1	2	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>93</b>	<b>44</b>	<b>11</b>	<b>29</b>	<b>17</b>	<b>6</b>	<b>3</b>

<i>Date:</i>	<i>14 Apr</i>	<i>15 Apr</i>	<i>16 Apr</i>	<i>17 Apr</i>	<i>18 Apr</i>	<i>19 Apr</i>	<i>20 Apr</i>
<i>Observation Time (Start):</i>	8:15	8:25	8:20	8:10	8:15	8:10	8:20
<i>Observation Time (End):</i>		17:40	19:00	19:10	18:45	19:20	19:00
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	--	--	--	1	14	17	23
0900 to 0959	--	--	--	8	55	23	45
1000 to 1059	--	--	15	7	15	46	26
1100 to 1159	--	--	25	20	6	25	17
1200 to 1259	--	--	57	5	10	31	7
1300 to 1359	--	--	32	6	14	63	19
1400 to 1459	--	--	5	21	24	57	29
1500 to 1559	1	3	5	45	42	62	27
1600 to 1659	--	--	4	44	25	89	49
1700 to 1759	--	--	8	58	20	75	37
1800 to 1859	--	--	--	25	6	43	50
1900 to 1959	--	--	--	4	--	8	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>1</b>	<b>3</b>	<b>151</b>	<b>244</b>	<b>231</b>	<b>539</b>	<b>329</b>

**Table 4**

**Continued.**

<i>Date:</i>	<i>21 Apr</i>	<i>22 Apr</i>	<i>23 Apr</i>	<i>24 Apr</i>	<i>25 Apr</i>	<i>26 Apr</i>	<i>27 Apr</i>
<i>Observation Time (Start):</i>	8:00	8:00	8:00	8:20	8:00	8:10	8:10
<i>Observation Time (End):</i>	9:00	18:45	18:45	18:45	18:50	18:25	18:35
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	9	49	3	2	4	4	--
0900 to 0959	37	45	5	3	1	0	--
1000 to 1059	38	12	3	3	2	1	--
1100 to 1159	5	43	5	5	0	0	--
1200 to 1259	4	14	6	8	9	0	--
1300 to 1359	60	13	10	6	9	0	--
1400 to 1459	78	14	14	17	9	1	--
1500 to 1559	55	15	4	14	39	0	--
1600 to 1659	71	13	2	11	25	0	--
1700 to 1759	28	9	1	14	18	0	--
1800 to 1859	42	6	0	4	11	0	--
1900 to 1959	9	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>436</b>	<b>233</b>	<b>53</b>	<b>87</b>	<b>127</b>	<b>6</b>	<b>0</b>

<i>Date:</i>	<i>28 Apr</i>	<i>29 Apr</i>	<i>30 Apr</i>	<i>1 May</i>	<i>2 May</i>	<i>3 May</i>	<i>4 May</i>
<i>Observation Time (Start):</i>	9:00	8:10	8:10	8:30	8:05	8:05	8:10
<i>Observation Time (End):</i>	18:25	18:15	18:25	18:15	18:10	18:15	18:55
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	--	--	--	--	--	--	2
0900 to 0959	--	1	--	--	--	--	19
1000 to 1059	1	--	--	--	--	3	13
1100 to 1159	--	--	--	--	--	--	23
1200 to 1259	--	--	--	--	--	--	36
1300 to 1359	--	1	1	1	--	2	34
1400 to 1459	--	1	--	--	--	1	24
1500 to 1559	--	--	--	--	--	12	36
1600 to 1659	--	--	--	1	--	7	22
1700 to 1759	--	--	--	--	--	6	25
1800 to 1859	1	--	--	--	--	2	12
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>33</b>	<b>246</b>

**Table 4**

**Continued.**

<i>Date:</i>	<i>5 May</i>	<i>6 May</i>	<i>7 May</i>	<i>8 May</i>	<i>9 May</i>	<i>10 May</i>	<i>11 May</i>
<i>Observation Time (Start):</i>	<i>8:15</i>	<i>8:15</i>	<i>8:10</i>	<i>8:05</i>	<i>8:10</i>	<i>8:02</i>	<i>8:10</i>
<i>Observation Time (End):</i>	<i>18:15</i>	<i>18:15</i>	<i>18:20</i>	<i>17:50</i>	<i>18:00</i>	<i>16:45</i>	<i>16:20</i>
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	11	4	10	20	3	--	--
0900 to 0959	23	11	26	22	19	1	--
1000 to 1059	32	14	17	6	20	--	--
1100 to 1159	42	25	18	1	21	--	--
1200 to 1259	38	15	5	8	4	--	--
1300 to 1359	38	18	2	9	8	1	--
1400 to 1459	24	13	0	10	3	2	--
1500 to 1559	29	10	6	2	6	1	--
1600 to 1659	22	21	23	1	1	--	--
1700 to 1759	13	18	19	--	2	--	--
1800 to 1859	4	8	7	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>276</b>	<b>157</b>	<b>133</b>	<b>79</b>	<b>87</b>	<b>5</b>	<b>0</b>

<i>Date:</i>	<i>12 May</i>	<i>13 May</i>	<i>14 May</i>	<i>15 May</i>	<i>16 May</i>	<i>17 May</i>	<i>18 May</i>
<i>Observation Time (Start):</i>	<i>8:00</i>	<i>8:00</i>	<i>8:00</i>	<i>8:50</i>	<i>8:20</i>		
<i>Observation Time (End):</i>	<i>16:20</i>	<i>16:30</i>	<i>16:30</i>	<i>17:20</i>	<i>12:00</i>		
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--		
0800 to 0859	--	1	--	11	--		
0900 to 0959	--	--	--	35	2		
1000 to 1059	--	--	1	12	--		
1100 to 1159	--	--	3	3	6		
1200 to 1259	--	--	--	2	--		
1300 to 1359	--	--	--	--	--		
1400 to 1459	--	--	--	--	--		
1500 to 1559	1	--	--	2	--		
1600 to 1659	--	--	--	--	--		
1700 to 1759	--	--	--	--	--		
1800 to 1859	--	--	--	--	--		
1900 to 1959	--	--	--	--	--		
2000 to 2059	--	--	--	--	--		
<b>Total</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>65</b>	<b>8</b>	<b>0</b>	<b>0</b>

Table 4

Continued.

<i>Date:</i>	19 May	20 May	21 May	22 May	23 May	24 May	25 May
<i>Observation Time (Start):</i>	8:20	8:15	8:20	7:50	8:00	7:55	7:30
<i>Observation Time (End):</i>	16:25	16:15	16:20	16:30	16:45	16:50	16:15
<b>Military Time (hrs)</b>							
0700 to 0759	--	--	--	--	--	--	2
0800 to 0859	--	--	--	2	--	26	4
0900 to 0959	--	--	1	4	10	17	4
1000 to 1059	--	--	5	5	4	21	3
1100 to 1159	--	1	1	5	2	15	4
1200 to 1259	--	--	--	9	2	14	--
1300 to 1359	--	1	2	5	5	2	--
1400 to 1459	1	2	3	2	4	1	--
1500 to 1559	--	--	--	2	2	--	--
1600 to 1659	1	--	1	3	1	--	--
1700 to 1759	--	--	--	--	--	--	--
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>2</b>	<b>4</b>	<b>13</b>	<b>37</b>	<b>30</b>	<b>96</b>	<b>17</b>

<i>Date:</i>	26 May	27 May	28 May	29 May	30 May	31 May	1 Jun
<i>Observation Time (Start):</i>	7:10	7:10	7:20	7:20	7:10	8:00	7:25
<i>Observation Time (End):</i>	16:43	16:15	15:30	15:30	15:20	15:30	15:30
<b>Military Time (hrs)</b>							
0700 to 0759	5	5	11	--	1	--	--
0800 to 0859	16	10	42	--	4	1	--
0900 to 0959	9	12	14	--	1	--	--
1000 to 1059	6	18	4	--	1	--	--
1100 to 1159	8	5	16	--	--	--	--
1200 to 1259	5	8	7	--	--	--	--
1300 to 1359	7	14	2	--	--	--	--
1400 to 1459	22	4	3	--	--	--	--
1500 to 1559	16	12	--	--	--	--	--
1600 to 1659	4	--	--	--	--	--	--
1700 to 1759	--	--	--	--	--	--	--
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
<b>Total</b>	<b>98</b>	<b>88</b>	<b>99</b>	<b>0</b>	<b>7</b>	<b>1</b>	<b>0</b>



**Table 5****Holtwood fishway summary table evaluating American shad passage at three river flow ranges.**

	1997	1998*	1999	2000*	2001	2002*	2003*
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun
Season duration (days)	58	47	40	40	43	55	36
Number of days of operation	55	41	40	36	42	35	34
Am. shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135
Am. shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254
<b>River flow ≤40,000 cfs</b>							
Number of days	48	22	34	19	40	19	15
Percent of season	87%	54%	85%	53%	95%	54%	44%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348
Percent of total passage	93%	91%	98%	67%	99%	59%	80%
<b>River flow 40,001 to 60,000 cfs</b>							
Number of days	7	2	6	12	2	14	18
Percent of season	13%	5%	15%	33%	5%	40%	53%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019
Daily ave. of Am. shad passed	266	115	106	795	317	502	279
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%
<b>River flow &gt;60,000 cfs</b>							
Number of days	0	17	0	5	0	2	1
Percent of season	0%	41%	0%	14%	0%	6%	3%
No. of Am. shad passed	0	493	0	173	0	171	6
Daily ave. of Am. shad passed	0	29	0	35	0	86	6
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%

\* Denotes seasons of high river flow or frequent spillage.

**Table 5 (continued)**

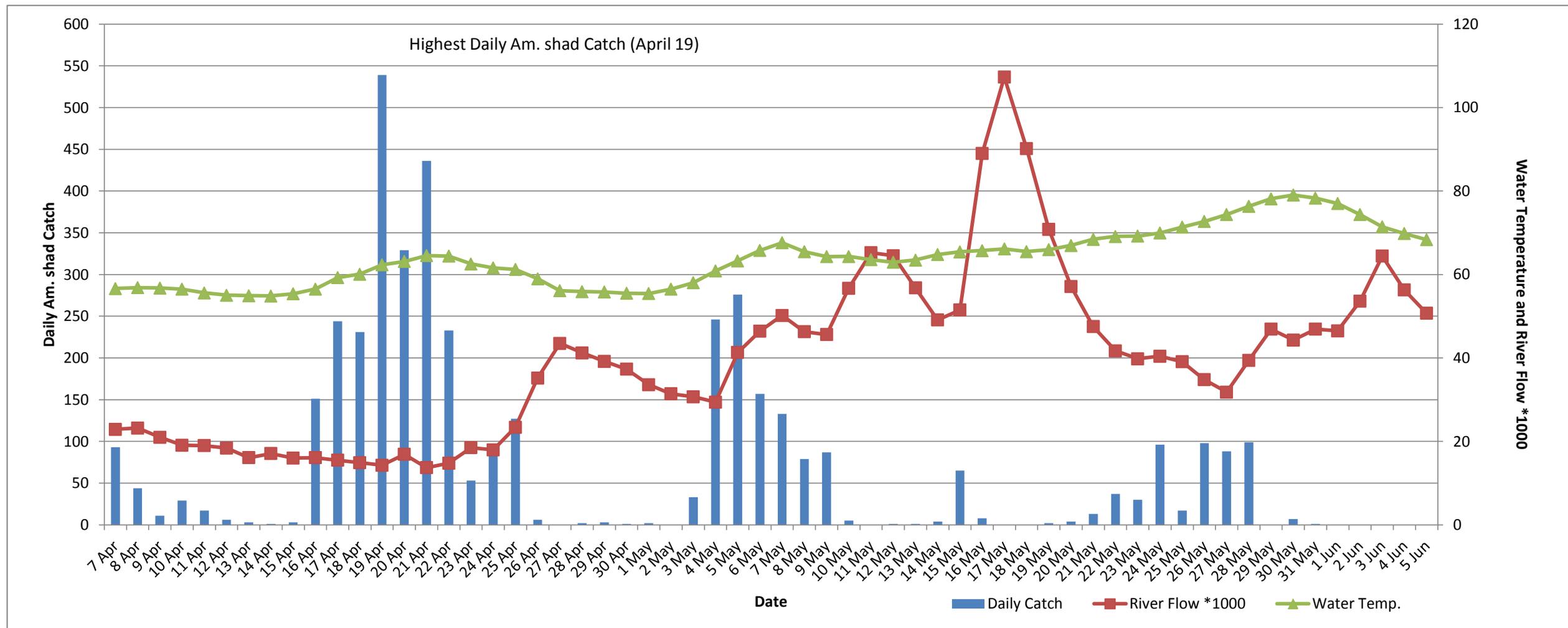
**Holtwood fishway summary table evaluating American shad passage at three river flow ranges.**

	2004*	2005	2006	2007	2008*	2009*	2010	2011*	2012*
Migration season start date	26 Apr	27 Apr	11 Apr	01 May	21 Apr	03 May	21 Apr	20 May	07 Apr
Migration season end date	03 Jun	10 Jun	06 Jun	04 Jun	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun
Season duration (days)	39	45	57	35	50	36	50	17	60
Number of days of operation	39	36	57	35	49	36	48	10	58
Am. shad season total (Conowingo)	109,360	68,926	56,899	25,464	19,914	29,272	37,757	20,571	22,143
Am. shad season total (Holtwood)	3,428	34,189	35,968	10,338	2,795	10,896	16,472	21	4,238
<b>River flow ≤40,000 cfs</b>									
Number of days	2	33	48	27	20	20	40	0	31
Percent of season	5%	92%	84%	77%	40%	56%	83%	0%	53%
No. of Am. shad passed	2	34,060	35,302	9,549	2,242	8,939	15,606	0	3260
Daily ave. of Am. shad passed	1	1,032	735	354	112	447	372	0	105
Percent of total passage	0%	99.6%	98.1%	92.3%	80.2%	82%	95%	0%	76.9%
<b>River flow 40,001 to 60,000 cfs</b>									
Number of days	20	3	5	8	22	14	8	2	18
Percent of season	51.3%	8%	9%	23%	44%	39%	17%	12%	30.0%
No. of Am. shad passed	1,943	129	566	789	533	1,846	866	0	967
Daily ave. of Am. shad passed	97	43	113	99	24	132	108	0	54
Percent of Total Passage	56.7%	0.4%	1.6%	7.6%	19.0%	17.0%	5%	0.0%	22.8%
<b>River flow &gt;60,000 cfs</b>									
Number of days	17	0	4	0	8	2	0	15	4
Percent of season	43.6%	0%	7%	0%	16%	5%	0%	88%	6.7%
No. of Am. shad passed	1,483	0	100	0	20	111	0	21	11
Daily ave. of Am. shad passed	87	0	25	0	2	55	0	2	3
Percent of total passage	43.3%	0.0%	0.3%	0.0%	0.7%	1.0%	0%	100%	0.3%

\* Denotes seasons of high river flow or frequent spillage.

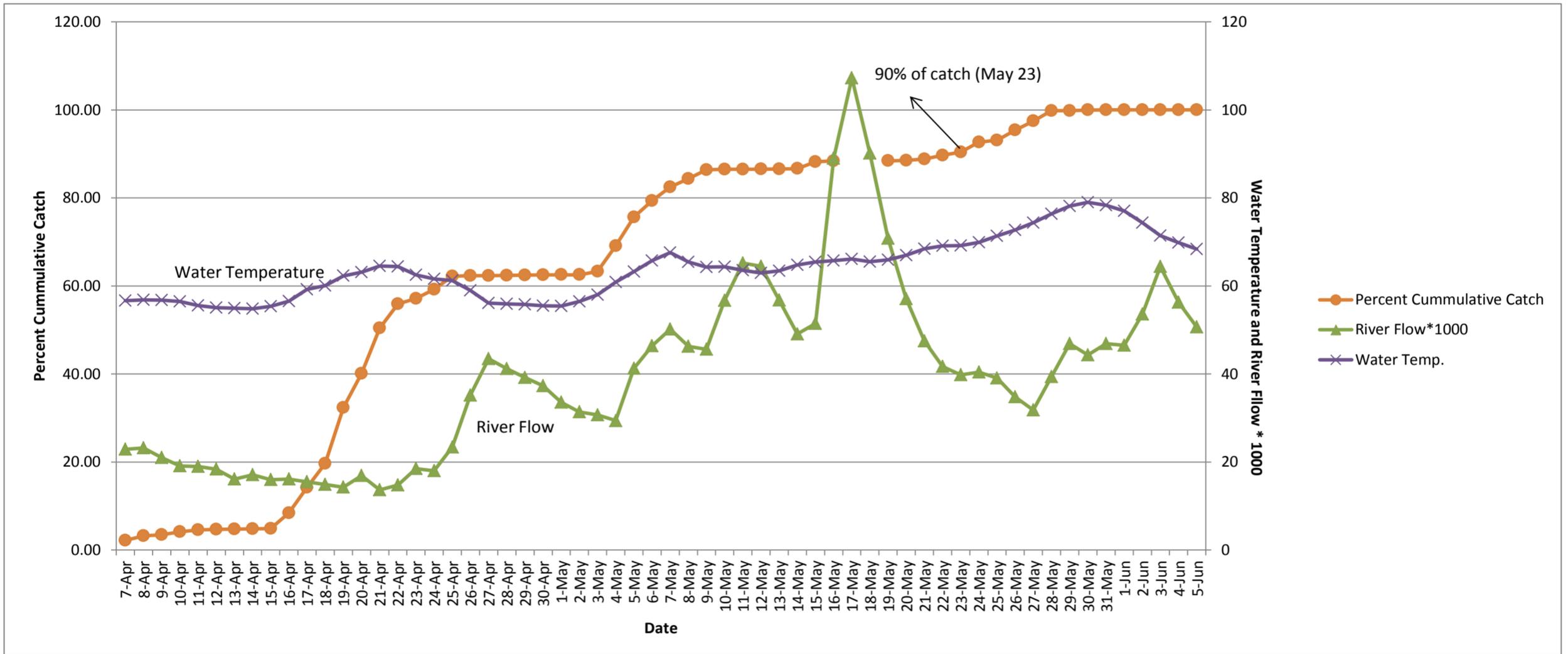
**Table 6****Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2012.**

Year	Conowingo East		Holtwood		Safe Harbor		York Haven	
	Am. shad catch	Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.	
1997	90,971	28,063	30.8%	20,828	74.2%	-	-	
1998	39,904	8,235	20.6%	6,054	73.5%	-	-	
1999	69,712	34,702	49.8%	34,150	98.4%	-	-	
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%	
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%	
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%	
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%	
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%	
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%	
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%	
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%	
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%	
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%	
2010	37,757	16,472	43.6%	12,706	77.1%	907	7.1%	
2011	20,571	21	0.1%	8	38.1%	0	0.0%	
<b>2012</b>	<b>22,143</b>	<b>4,238</b>	<b>19.1%</b>	<b>3,089</b>	<b>72.9%</b>	<b>224</b>	<b>7.3%</b>	



**Figure 1**

**A plot of river flow (x 1000) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2012. No operation due to high flow event (May 17-18).**



**Figure 2**

**A plot of river flow (x 1000 cfs) and water temperature (°F) in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2012. No operation due to high flow event (May 17-18).**