SUMMARY OF OPERATIONS AT THE HOLTWOOD FISH PASSAGE FACILITY SPRING 2013

October 2013

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EXECUTIVE SUMMARY

Operations at the Holtwood fish passage facility began on April 29, 2013. The tailrace lift was operated for 38 days while the spillway lift operated 36 days. Lift operations were terminated for the season, with agency concurrence, on June 5, 2013. The 2013 fish passage season marks the seventeenth year of operation at Holtwood.

The lifts passed 466,518 fish of 29 taxa. Gizzard shad and American shad, walleye, shorthead redhorse, and comely shiners dominated the catch, and comprised nearly 99% of the total fish collected and passed. American shad and alewife (residualized) represented the two *Alosa* species collected and passed at Holtwood in 2013.

A total of 2,503 American shad were passed by the Holtwood fishway in 2013. Some 1,770 American shad (71% of total shad catch) were passed in the tailrace lift while the spillway lift accounted for 733 American shad (29% of total shad catch). Collection and passage of shad varied daily with nearly 95% of total shad (2,364) passed prior to May 29. The highest daily American shad catch occurred on May 9 when 385 shad moved upstream during 10.3 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 1200 hrs and 1659 hrs.

Fishway operations were conducted at water temperatures ranging from 59.6°F to 78.5°F and river flows between 20,700 and 48,000 cfs. Spillage occurred on 25 of the 38 days of operation, (65% of the season). Two of the days when spillage occurred resulted from the station taking units off line to conduct emergency equipment repairs in the existing powerhouse. River water temperatures fluctuated between 60°F and 70°F for most of the season with river flows relatively stable after May 14 to season end. American shad of advanced or post-spawned condition were observed during fish passage operations from late-May to the end of the season.

For most of the season, water clarity was adequate, allowing the viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2013 was 3 pink tags; all from this year's hook and line tagging effort.

The 2013 American shad passage rate at Holtwood (19.7% of American shad passing Conowingo passed Holtwood) was below the historical average of 30.3% (1997-2012). However, passage of American shad by the spillway lift in 2012 and 2013 has been higher than previous years dating back to 2003, possibly due to modifications completed in the Piney Channel as part of redevelopment activities, redirecting the Unit 1 turbine discharge to the Piney Channel and completion of repairs to Entrance Gate "C".

A low, stable, river flow appears to be critical for enhancing American shad passage rates. We documented 94% of American shad passed Holtwood at river flows less than 40,000 cfs, with 6% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. Future operations of the fishway will build on the past seventeen years of operation experience.

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1.0 INTRODUCTION

On June 1, 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 (PPL Holtwood LLC) 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 April 1, 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 2013. This year marked the seventeenth operational season.

Objectives of 2013 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 currently 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 Holtwood spillway are controlled by numerous factors that change hourly, daily and throughout the fishway operating season. The primary factors are natural river flows, operation of the power station, installation and integrity of the flash boards along with one Obermeyer gate, and operation of the Safe Harbor Hydroelectric Project.

In spring 2013, all rubber dams were inoperable (not inflated) due to irreparable damage that occurred in previous years and current redevelopment activities. One Obermeyer gate has been installed closest to the fishway exit and wooden flashboards have been installed in place of the rubber dam sections. Operations began at the Holtwood Fish Lift facility on April 29, after the passage of one-thousand shad at Conowingo Dam on April 26. Since river flows were greater than station capacity, spill occurred on 25 of 38 days of fish lift operation, (Table 1). In 2013, station capacity was limited to eight operating units due to various redevelopment activities. Passage operations ended on June 5, with agency concurrence, due to increasing water temperatures, and low American shad passage.

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 flows, throughout the entire facility, are 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.

Four inflatable rubber dams, operated from the hydro control room, had been an integral component of effective spillway lift operation. Prior to fish lift operations in 2013, the rubber dam closest to the fishway exit was replaced with an Obermeyer gate, with flashboards installed upstream of the other three damaged rubber dams to maintain forebay water levels.

Design guidelines for fishway operation include six entrance combinations. These are: (1) entrances A, B, and C; (2) entrances A and B; (3) entrances A and C; (4) Entrance A only; (5) Entrance B only; and (6) 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 2013, the following gate combinations were utilized: Entrances A, B, and C (2 days); Entrances A and C (29 days); Entrances A and B (2 days); Entrance A only (3 days); and Entrance C only (2 days). The spillway lift, (Entrance gate C), is used less frequently when river flows are greater than 40,000 cfs or flashboard sections are damaged/missing because spillage may mask or interfere with the attraction flow from spillway entrance gate C.

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. Pre-season equipment preparations began in March, and were completed before season start-up.

The passage of more than 1,000 American shad at Conowingo Dam on April 26 triggered the start of Holtwood operations on April 29. This year we recorded 38 days of operation. The tailrace lift operated on all 38 days while the spillway lift operated on 36 days this season. 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 flash drive and stored on-site. Daily reports and weekly summaries of fish passage numbers are electronically distributed to members of the Holtwood FPTAC and other co-operators.

3.0 RESULTS

3.1 Relative Abundance

The diversity and abundance of fishes collected and passed daily in the Holtwood fishway during the spring 2013 operational period is presented in Table 2. A total of 466,518 fish of 29 taxa passed upstream into Lake Aldred. Gizzard shad (418,310), comely shiner (39,105), American shad (2,503), walleye (1,504), channel catfish (1,131), and shorthead redhorse (1,035) comprised nearly 99% of all fishes passed. Other abundant fishes passed included quillback (735), carp (725), smallmouth bass (645) and spotfin shiner (605). The peak one-day passage of all species occurred on May 12, when 34,997 fish were passed, comprised mostly of gizzard shad (34,460), walleye (137), carp (132), and American shad (108).

3.2 American Shad Passage

A total of 2,503 American shad were passed at Holtwood during 2013; 1,770 American shad passed in the tailrace lift while the spillway lift accounted for 733 American shad (Table 3). Collection and passage of shad varied daily with nearly 95% of total shad (2,364) passed prior to May 29 (Figures 1 and 2). The highest daily shad catch occurred on May 9 when 385 shad moved upstream during 10.3 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 1200 hrs and 1659 hrs (Table 4). Fishway operations were conducted at water temperatures ranging from 59.6°F to 78.5°F and river flows between 20,700 and 48,000 cfs. Spillage occurred on 25 of the 38 days of operation, (65% of the season). Two days when spillage occurred resulted from the station taking units off line to conduct emergency equipment repairs in the existing powerhouse.

The capture of shad at the fishway occurred over a relatively wide range of station operation and discharge conditions (Table 1). Shad were attracted to the tailrace lift at water elevations ranging from 107.9 ft to 114 ft. Tailrace elevations correspond to unit operation, which varied from 0 to 7 units. During spring 2013, tailrace fishway operation generally coincided with a seven turbine operation/generation scenario. Spillway lift operation now occurs with Unit #1 discharging into the spillway and during periods of no or minimal spillage, (spillway water elevation 116 to 119 ft), or when the forebay level is high enough to allow simultaneous operation of both the spillway and tailrace fish lifts, which occurred more often this season because river flows generally ranged between 20,000 cfs and 40,000 cfs and the flashboards were intact from May 9 to end of season.

Passage of shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 163.9 ft to 171.5 ft (Table 1). Forebay elevations during passage operations ranged from 167 ft to 170 ft for approximately 58% of the 2013 season. Spillage occurs, with all flashboards intact, at forebay elevations greater than 169.75 ft.

The hourly passage numbers of American shad at Holtwood are provided in Table 4. A total of 1,453 American shad passed through the fishway between 1200 hrs and 1659 hrs (58% of total passage). Overall, shad passage was highest from 1500 hrs to 1659 hrs, and then sharply declined until operation was ended each evening.

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 thirty six days in an effort to pass any shad attracted into the spillway area adjacent to the fish lift. 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, 1,770 and 733 shad were captured in the tailrace and spillway lifts over the total operating period in 2013, respectively (Table 3). The percentage of American shad passed by the spillway lift in 2012 and 2013 was higher than previous years dating back to 2003, possibly due to modifications made to the Piney Channel during redevelopment activities.

3.3 Other Alosids

A small number of residualized alewife (8) was passed at Holtwood this season. No other herring or hickory shad were observed.

3.4 Maryland DNR tag-recapture

For most of the season, water clarity ranged from 22 to 28 inches of visibility, allowing the viewing technicians to accurately identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2013 was 3 pink tags; all from this season's tagging efforts downstream of Conowingo Dam.

3.5 Passage Evaluation

In spring 2013, 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. A low, stable, river flow appears to be critical for enhancing American shad passage rates. We documented 94% of American shad passed at river flows less than 40,000 cfs, with 6% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. During fish lift operations in 2013, river flows ranged from 20,700 cfs to 48,000 cfs. The 2013 American shad passage rate at Holtwood (19.7% of American shad passed at Conowingo were passed by Holtwood), was below the historical average of 30.3% observed at Holtwood from 1997 to 2012 (Table 6).

We seek to optimize future fishway operations by utilizing knowledge gained through these seventeen 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.

4.0 RECOMMENDATIONS

1) Continue 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 daily average river flow, water temperature, unit operation, fishway weir gate operation, and project water elevations

	Am. shad	River Flow	Ave.Water	Secchi	Number	Weir Gate Operation			Elevation (ft)		
Date	Catch	(cfs)	Temp. (°F)	(in)	of Units	A	B	C*	Tailrace	Spillway	Forebay
29 Apr	91	38,900	60.60	28	8	X	X	X	112	Spill	168
30 Apr	133	36,400	60.40	28	8			X	111	Spill	167
1 May	46	34,700	59.60	28	8	X		X	112	Spill	168
2 May	88	32,200	60.20	28	8	X		X	111.7	Spill	166
3 May	142	29,800	61.10	28	6		X	X	110	Spill	167
4 May	164	28,000	62.30	28	6	X		X	109	Spill	165.5
5 May	205	26,300	64.20	28	8	X		X	113	Spill	166
6 May	80	24,100	64.90	26	8	X			111	Spill	165
7 May	9	22,700	64.40	28	7	X			110.9	120	163.9
8 May	16	22,000	64.80	28	8	X			111.5	120	164
9 May	385	26,000	65.00	28	6			X	112.3	120	165.7
10 May	326	32,600	66.20	24	8	X		X	110.5	Spill	168.5
11 May	165	36,500	67.80	24	8	X		X	113	Spill	171
12 May	108	40,200	68.20	24	8	X		X	113.2	Spill	169.5
13 May	30	47,200	67.00	24	8	X		X	111.9	Spill	170.9
14 May	8	48,000	63.70	24	8	X		X	114	Spill	171.5
15 May	2	43,600	61.40	24	8	X	X	X	113	Spill	170
16 May	1	38,900	61.00	24	8	X		X	113.5	Spill	170.4
17 May	8	34,900	61.90	24	8	X		X	112	Spill	170
18 May	15	31,500	63.90	24	8	X		X	111	Spill	169
19 May	4	28,300	65.10	22	8	X		X	113	Spill	170
20 May	21	25,900	66.60	24	8	X		X	113	121	169
21 May	49	23,800	67.30	25	8	X		X	110	121	169
22 May	40		67.80	26	8	X		X	110.5	121	168
23 May	28	20,900	69.90	27	8	X		X	111.5	121	168
24 May	152	20,700	70.70	24-10	0		X	X	107.9	Spill	171

Table 1
Continued.

Date	Am. shad Catch	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Number of Units	Weir Gate Operation			Elevation (ft)		
						A	B	C	Tailrace	Spillway	Forebay
25 May	26	21,700	70.50	22-16	0		X		110	Spill	171
26 May	5	20,700	69.30	22-14	8	X		X	110	121	168
27 May	3	21,900	68.20	22-18	6	X		X	111.5	121	167.5
28 May	14	24,100	67.40	22	8	X		X	112	121	169
29 May	51	23,300	65.40	23	8	X		X	111.5	121	168
30 May	32	23,000	66.60	24	8	X		X	113.3	121	168.8
31 May	14	27,500	69.40	25	8	X		X	112	Spill	169
1 Jun	17	29,100	72.50	26	8	X		X	114	Spill	170
2 Jun	14	30,300	75.80	27	8	X		X	112.8	Spill	170.5
3 Jun	4	34,300	78.50	22-18	8	X		X	112.3	Spill	171
4 Jun	4	30,700	78.40	22	7	X		X	110	Spill	170.5
5 Jun	3	25,500	77.40	22-18	7	X		X	111	121	169

Table 2

Summary of the daily number of fish passed by the Holtwood fish passage facility in 2013.

Date:	*29 Apr*	*30 Apr*	*1 May*	*2 May*	*3 May*	*4 May*	*5 May*	*6 May*	*7 May*	*8 May*
Hours of Operation - Tailrace:	7.7	9.1	9.9	10.4	10.6	10.5	10.4	10.5	10.3	8.5
Number of Lifts - Tailrace:	11	15	17	12	15	18	17	17	15	14
Hours of Operation - Spillway:	6.9	9.7	9.8	10.3	10.7	7.7	5.3	6.1	0.0	3.0
Number of Lifts - Spillway:	9	15	11	11	13	10	6	7	0	7
Water Temperature (°F):	60.6	60.4	59.6	60.2	61.1	62.3	64.2	64.9	64.4	64.8
AMERICAN SHAD	91	133	46	88	142	164	205	80	9	16
ALEWIFE	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	4947	14333	6799	4891	5527	6486	9995	10692	5042	10512
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
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	0	1	0	0	2	2	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	3	4	11	36	146	29	46	27	6	7
QUILLBACK	0	12	0	103	105	132	68	1	0	0
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0
S. REDHORSE	120	188	86	100	107	98	33	1	0	0
CHANNEL CATFISH	13	19	7	5	0	43	34	2	9	27
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
ROCK BASS	2	0	2	0	0	3	6	1	0	0
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	1	0	0	0
BLUEGILL	0	0	0	0	0	1	1	0	0	0
SMALLMOUTH BASS	67	140	131	80	24	39	18	7	2	21
LARGEMOUTH BASS	0	0	0	2	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	2	0	3	0	0	0	0
WALLEYE	20	39	56	30	16	39	45	6	3	13
COMELY SHINER	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0
NORTHERN HOGSUCKER	0	1	1	0	0	0	0	0	0	0
FLATHEAD CATFISH	0	0	2	0	0	0	0	0	0	0
	5,263	14,870	7,141	5,337	6,069	7,039	10,452	10,817	5,071	10,596

Table 2

Continued.

Date:	*9 May*	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*	*16 May*	*17 May*	*18 May*
Hours of Operation - Tailrace:	10.0	10.2	10.7	10.5	10.2	9.3	9.8	9.6	9.8	9.7
Number of Lifts - Tailrace:	13	15	20	20	20	15	14	12	13	15
Hours of Operation - Spillway:	10.3	10.7	10.3	10.2	10.4	3.5	9.8	9.7	9.7	9.6
Number of Lifts - Spillway:	17	16	15	11	8	4	10	7	13	12
Water Temperature (°F):	65	66.2	67.8	68.2	67	63.7	61.4	61	61.9	63.9
AMERICAN SHAD	385	326	165	108	30	8	2	1	8	15
ALEWIFE	0	0	0	0	0	0	8	0	0	0
GIZZARD SHAD	17995	17393	33299	34460	25819	11430	1241	4763	6596	18980
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	1	0	0	0	0	0	0	1
RAINBOW TROUT	0	1	0	0	0	0	0	0	0	0
BROWN TROUT	2	2	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	1	0	0	0	0	0	0	0	0
CARP	7	8	83	132	16	10	1	0	1	7
QUILLBACK	13	26	145	27	10	0	0	0	0	4
WHITE SUCKER	0	0	0	1	0	0	0	0	0	0
S. REDHORSE	7	11	58	56	11	0	0	0	1	5
CHANNEL CATFISH	14	56	96	66	9	6	22	0	1	13
WHITE PERCH	0	1	2	0	0	0	0	0	0	1
ROCK BASS	0	1	8	1	0	0	1	0	0	3
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	1	0	3	0	0	0	0	0	0	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	5	0	0	0	0	0	0	3
SMALLMOUTH BASS	22	19	27	8	6	1	0	1	1	4
LARGEMOUTH BASS	0	0	0	1	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	1	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	1	0	0	0	0	0
WALLEYE	6	102	141	137	113	23	29	14	10	35
COMELY SHINER	0	0	0	0	0	0	0	0	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0	0
FLATHEAD CATFISH	0	0	0	0	0	0	1	0	0	0
	18,452	17,947	34,034	34,997	26,015	11,478	1,305	4,779	6,618	19,071

Table 2

Continued.

Date:	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*
Hours of Operation - Tailrace:	10.0	9.6	9.8	10.7	9.7	10.7	10.3	9.7	9.8	10.3
Number of Lifts - Tailrace:	17	16	18	18	15	16	17	13	15	17
Hours of Operation - Spillway:	5.7	9.5	9.8	10.4	7.4	4.2	0.0	9.6	9.7	10.3
Number of Lifts - Spillway:	7	13	12	13	7	3	0	9	11	12
Water Temperature (°F):	65.1	66.6	67.3	67.8	69.9	70.7	70.5	69.3	68.2	67.4
AMERICAN SHAD	4	21	49	40	28	152	26	5	3	14
ALEWIFE	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	18046	15560	26349	17939	18674	6428	2771	9220	6307	5481
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	1	1	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	1	2	0	0	0
BROWN TROUT	0	0	0	0	0	1	0	2	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	1
CARP	4	9	0	13	0	4	0	1	3	0
QUILLBACK	2	10	2	3	28	6	0	1	0	1
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0
S. REDHORSE	0	10	8	5	1	0	0	2	9	0
CHANNEL CATFISH	14	1	1	14	5	23	20	6	5	12
WHITE PERCH	0	0	0	0	0	1	0	0	0	0
ROCK BASS	4	0	0	0	0	0	0	1	1	0
REDBREAST SUNFISH	0	0	0	0	0	0	1	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	1	0	1	0
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	4	1	0	7	0	5	3	7	2	0
SMALLMOUTH BASS	1	6	4	3	4	0	1	0	0	0
LARGEMOUTH BASS	0	0	1	0	0	0	0	0	0	0
WHITE CRAPPIE	1	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	1	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	56	75	46	31	41	36	11	13	13	26
COMELY SHINER	0	0	0	0	0	0	2650	550	0	0
SPOTFIN SHINER	0	0	0	0	0	0	0	0	0	0
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	0	0
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0
	18,136	15,694	26,461	18,055	18,781	6,657	5,486	9,809	6,344	5,535

Table 2

Continued.

Date:	*29 May*	*30 May*	*31 May*	*1 Jun*	*2 Jun*	*3 Jun*	*4 Jun*	*5 Jun*	***TOTAL***
Hours of Operation - Tailrace:	10.1	10.5	9.8	9.6	10.1	9.6	9.5	6.6	***373.5***
Number of Lifts - Tailrace:	17	12	14	16	12	16	14	9	***580.0***
Hours of Operation - Spillway:	8.3	10.6	9.9	9.5	9.8	9.5	8.1	6.7	***312.5***
Number of Lifts - Spillway:	10	10	12	12	7	11	9	7	***367.0***
Water Temperature (°F):	65.4	66.6	69.4	72.5	75.8	78.5	78.4	77.4	
AMERICAN SHAD	51	32	14	17	14	4	4	3	***2,503***
ALEWIFE	0	0	0	0	0	0	0	0	***8***
GIZZARD SHAD	7715	4890	10047	9190	3047	2430	1701	1315	***418,310***
STRIPED BASS	0	0	1	2	0	0	0	0	***3***
SEA LAMPREY	0	0	0	2	0	0	0	0	***6***
RAINBOW TROUT	0	0	0	2	0	0	0	0	***6***
BROWN TROUT	0	0	0	0	0	0	0	0	***12***
MUSKELLUNGE	0	0	0	0	0	0	0	0	***2***
CARP	0	6	8	24	20	26	25	2	***725***
QUILLBACK	0	4	0	0	14	12	0	6	***735***
WHITE SUCKER	0	0	0	0	0	0	0	0	***1***
S. REDHORSE	1	0	3	13	33	49	9	10	***1,035***
CHANNEL CATFISH	7	6	16	145	60	236	79	39	***1,131***
WHITE PERCH	1	0	1	0	0	0	0	0	***7***
ROCK BASS	0	0	0	1	1	0	0	0	***36***
REDBREAST SUNFISH	0	0	0	0	0	0	0	0	***1***
GREEN SUNFISH	1	1	1	10	2	0	0	2	***23***
PUMPKINSEED	0	0	0	0	0	0	0	0	***1***
BLUEGILL	3	2	3	20	7	7	0	5	***86***
SMALLMOUTH BASS	0	2	1	1	0	1	3	0	***645***
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	***4***
WHITE CRAPPIE	1	0	0	3	0	1	0	0	***6***
BLACK CRAPPIE	0	0	1	0	0	0	0	0	***3***
YELLOW PERCH	0	0	0	0	0	0	0	0	***6***
WALLEYE	12	32	26	79	40	55	27	8	***1,504***
COMELY SHINER	0	0	0	4200	0	14500	6705	10500	***39,105***
SPOTFIN SHINER	0	0	0	400	0	205	0	0	***605***
NORTHERN HOGSUCKER	0	0	0	0	0	0	0	0	***2***
FLATHEAD CATFISH	0	0	0	0	2	1	0	1	***7***
	7,792	4,975	10,122	14,109	3,240	17,527	8,553	11,891	**466,518**

Table 3

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2013.

	Shad	Number Collected		Percent Collected	
Date	Catch	Tailrace	Spillway	Tailrace	Spillway
29-Apr	91	86	5	95%	5%
30-Apr	133	80	53	60%	40%
1-May	46	23	23	50%	50%
2-May	88	27	61	31%	69%
3-May	142	85	57	60%	40%
4-May	164	107	57	65%	35%
5-May	205	195	10	95%	5%
6-May	80	60	20	75%	25%
7-May	9	9	0	100%	0%
8-May	16	13	3	81%	19%
9-May	385	154	231	40%	60%
10-May	326	244	82	75%	25%
11-May	165	132	33	80%	20%
12-May	108	97	11	90%	10%
13-May	30	15	15	50%	50%
14-May	8	8	0	100%	0%
15-May	2	2	0	100%	0%
16-May	1	1	0	100%	0%
17-May	8	2	6	25%	75%
18-May	15	0	15	0%	100%
19-May	4	2	2	50%	50%
20-May	21	14	7	67%	33%
21-May	49	37	12	76%	24%
22-May	40	32	8	80%	20%
23-May	28	27	1	96%	4%
24-May	152	152	0	100%	0%
25-May	26	26	0	100%	0%
26-May	5	3	2	60%	40%
27-May	3	3	0	100%	0%
28-May	14	9	5	64%	36%
29-May	51	46	5	90%	10%
30-May	32	30	2	94%	6%
31-May	14	10	4	71%	29%
1-Jun	17	15	2	88%	12%
2-Jun	14	14	0	100%	0%
3-Jun	4	3	1	75%	25%
4-Jun	4	4	0	100%	0%
5-Jun	3	3	0	100%	0%
Total	**2,503**	**1,770**	**733**	**71%**	**29%**

Table 4

Hourly summary of American shad passage at the Holtwood fish passage facility in 2013.

Date:	29-Apr	30-Apr	1-May	2-May	3-May	4-May	5-May
Observation Time (Start):	11:00	8:20	8:50	8:15	8:01	8:15	8:15
Observation Time (End):	18:20	19:00	18:50	18:55	18:55	19:00	18:50
Military Time (hrs)							
0700 to 0759							
0800 to 0859		0		3	1	1	6
0900 to 0959		4	3	5	15	10	12
1000 to 1059		5	5	0	9	8	7
1100 to 1159	0	13	1	2	9	10	12
1200 to 1259	0	27	0	3	14	15	15
1300 to 1359	1	9	6	14	29	11	30
1400 to 1459	11	6	5	8	23	12	35
1500 to 1559	20	27	3	14	15	31	40
1600 to 1659	34	20	9	18	12	22	30
1700 to 1759	21	10	6	12	8	12	11
1800 to 1859	4	12	8	9	7	32	7
1900 to 1959							
Total	**91**	**133**	**46**	**88**	**142**	**164**	**205**

Date:	6-May	7-May	8-May	9-May	10-May	11-May	12-May
Observation Time (Start):	8:14	8:00	8:00	8:10	8:00	8:00	8:15
Observation Time (End):	18:50	18:30	19:50	18:30	19:00	19:00	19:00
Military Time (hrs)							
0700 to 0759							
0800 to 0859	5	0	0	6	1	5	13
0900 to 0959	9	2	0	24	16	15	20
1000 to 1059	1	0	3	63	15	27	8
1100 to 1159	4	1	1	82	6	28	5
1200 to 1259	0	0	2	65	51	11	4
1300 to 1359	1	0	2	23	68	14	5
1400 to 1459	1	0	0	14	75	9	8
1500 to 1559	8	3	2	52	49	12	9
1600 to 1659	11	0	3	44	29	7	13
1700 to 1759	18	0	2	10	11	19	13
1800 to 1859	22	3	0	2	5	18	10
1900 to 1959			1				
Total	**80**	**9**	**16**	**385**	**326**	**165**	**108**

Table 4

Continued.

Date:	13-May	14-May	15-May	16-May	17-May	18-May	19-May
Observation Time (Start):	7:55	8:04	7:50	7:55	8:00	7:50	7:30
Observation Time (End):	18:25	18:15	17:45	17:55	17:50	17:45	17:45
Military Time (hrs)							
0700 to 0759			1				0
0800 to 0859	10	1	1	0	1	3	0
0900 to 0959	1	0	0	1	1	1	0
1000 to 1059	1	2	0	0	0	0	0
1100 to 1159	0	0	0	0	0	3	0
1200 to 1259	3	1	0	0	0	3	1
1300 to 1359	3	1	0	0	4	3	2
1400 to 1459	4	2	0	0	0	0	0
1500 to 1559	3	1	0	0	1	1	0
1600 to 1659	0	0	0	0	0	1	1
1700 to 1759	2	0	0	0	1	0	0
1800 to 1859	3	0					
1900 to 1959							
Total	**30**	**8**	**2**	**1**	**8**	**15**	**4**

Date:	20-May	21-May	22-May	23-May	24-May	25-May	26-May
Observation Time (Start):	8:00	7:55	7:00	7:55	8:00	7:25	7:35
Observation Time (End):	17:45	17:59	17:50	17:55	19:00	17:45	17:45
Military Time (hrs)							
0700 to 0759			6			0	0
0800 to 0859	2	1	2	4	6	5	0
0900 to 0959	1	5	5	6	11	1	0
1000 to 1059	3	4	2	2	19	1	2
1100 to 1159	1	2	2	1	9	7	0
1200 to 1259	1	3	3	0	20	2	0
1300 to 1359	1	3	3	0	25	2	0
1400 to 1459	3	4	1	0	18	5	1
1500 to 1559	7	7	5	2	21	1	0
1600 to 1659	2	15	5	3	10	2	0
1700 to 1759	0	5	6	10	9		2
1800 to 1859					4		
1900 to 1959							
Total	**21**	**49**	**40**	**28**	**152**	**26**	**5**

Table 4

Continued.

Date:	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun
Observation Time (Start):	7:50	7:30	7:30	7:10	7:15	7:40	7:35
Observation Time (End):	17:45	17:50	17:45	17:52	17:15	17:50	17:50
Military Time (hrs)							
0700 to 0759		0	0	2	0	0	0
0800 to 0859	0	0	3	3	5	4	2
0900 to 0959	0	1	2	5	1	3	5
1000 to 1059	0	1	3	1	0	6	2
1100 to 1159	0	2	5	4	4	0	0
1200 to 1259	0	1	9	2	1	1	2
1300 to 1359	0	1	4	0	3	0	1
1400 to 1459	2	0	4	3	0	2	1
1500 to 1559	1	1	5	4	0	0	1
1600 to 1659	0	4	13	6	0	1	0
1700 to 1759	0	3	3	2	0	0	0
1800 to 1859							
1900 to 1959							
Total	**3**	**14**	**51**	**32**	**14**	**17**	**14**

Date:	3-Jun	4-Jun	5-Jun	***Season Total***
Observation Time (Start):	8:10	8:00	7:50	
Observation Time (End):	17:45	17:30	15:30	
Military Time (hrs)				
0700 to 0759				9
0800 to 0859	0	0	0	94
0900 to 0959	2	2	0	189
1000 to 1059	0	1	0	201
1100 to 1159	0	0	0	214
1200 to 1259	1	1	2	264
1300 to 1359	1	0	1	271
1400 to 1459	0	0	0	257
1500 to 1559	0	0	0	346
1600 to 1659	0	0		315
1700 to 1759	0	0		196
1800 to 1859				146
1900 to 1959				1
Total	**4**	**4**	**3**	**2,503**

Table 5

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

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun
Season duration (days)	58	47	40	40	43	55	36	39
Number of days of operation	55	41	40	36	42	35	34	39
Am. shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135	109,360
Am. shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254	3,428
River flow ≤40,000 cfs								
Number of days	48	22	34	19	40	19	15	2
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%
No. of Am. shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2
Daily ave. of Am. shad passed	546	341	1,002	1,037	2,733	543	1,348	1
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%
River flow 40,001 to 60,000 cfs								
Number of days	7	2	6	12	2	14	18	20
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.3%
No. of Am. shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943
Daily ave. of Am. shad passed	266	115	106	795	317	502	279	97
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%	56.7%
River flow >60,000 cfs								
Number of days	0	17	0	5	0	2	1	17
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.6%
No. of Am. shad passed	0	493	0	173	0	171	6	1,483
Daily ave. of Am. shad passed	0	29	0	35	0	86	6	87
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.3%

* 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.

	2005	2006	2007	2008*	2009*	2010	2011	2012	2013
Migration season start date	27 Apr	11 Apr	01 May	21 Apr	03 May	21 Apr	20 May	07 Apr	29-Apr
Migration season end date	10 Jun	06 Jun	04 Jun	09 Jun	07 Jun	09 Jun	05 Jun	05 Jun	5-Jun
Season duration (days)	45	57	35	50	36	50	17	60	38
Number of days of operation	36	57	35	49	36	48	10	58	38
Am. shad season total (Conowingo)	68,926	56,899	25,464	19,914	29,272	37,757	20,571	22,143	12,733
Am. shad season total (Holtwood)	34,189	35,968	10,338	2,795	10,896	16,472	21	4,238	2,503
River flow ≤40,000 cfs									
Number of days	33	48	27	20	20	40	0	31	34
Percent of season	92%	84%	77%	40%	56%	83%	0%	53%	89%
No. of Am. shad passed	34,060	35,302	9,549	2,242	8,939	15,606	0	3260	2,355
Daily ave. of Am. shad passed	1,032	735	354	112	447	372	0	105	70
Percent of total passage	99.6%	98.1%	92.3%	80.2%	82%	95%	0%	77%	94%
River flow 40,001 to 60,000 cfs									
Number of days	3	5	8	22	14	8	2	18	4
Percent of season	8%	9%	23%	44%	39%	17%	12%	30.0%	11%
No. of Am. shad passed	129	566	789	533	1,846	866	0	967	148
Daily ave. of Am. shad passed	43	113	99	24	132	108	0	54	37
Percent of Total Passage	0.4%	1.6%	7.6%	19.0%	17.0%	5%	0.0%	22.8%	5.9%
River flow >60,000 cfs									
Number of days	0	4	0	8	2	0	15	4	0
Percent of season	0%	7%	0%	16%	5%	0%	88%	6.7%	0%
No. of Am. shad passed	0	100	0	20	111	0	21	11	0
Daily ave. of Am. shad passed	0	25	0	2	55	0	2	3	0
Percent of total passage	0.0%	0.3%	0.0%	0.7%	1.0%	0%	100%	0.3%	0%

* 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, 1997-2013.

	Conowingo	Holtwood		Safe Harbor		York Haven	
	East	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%
2012	22,143	4,238	19.1%	3,089	72.9%	224	7.3%
2013	**12,733**	**2,503**	**19.7%**	**1,927**	**77.0%**	**202**	**10.5%**

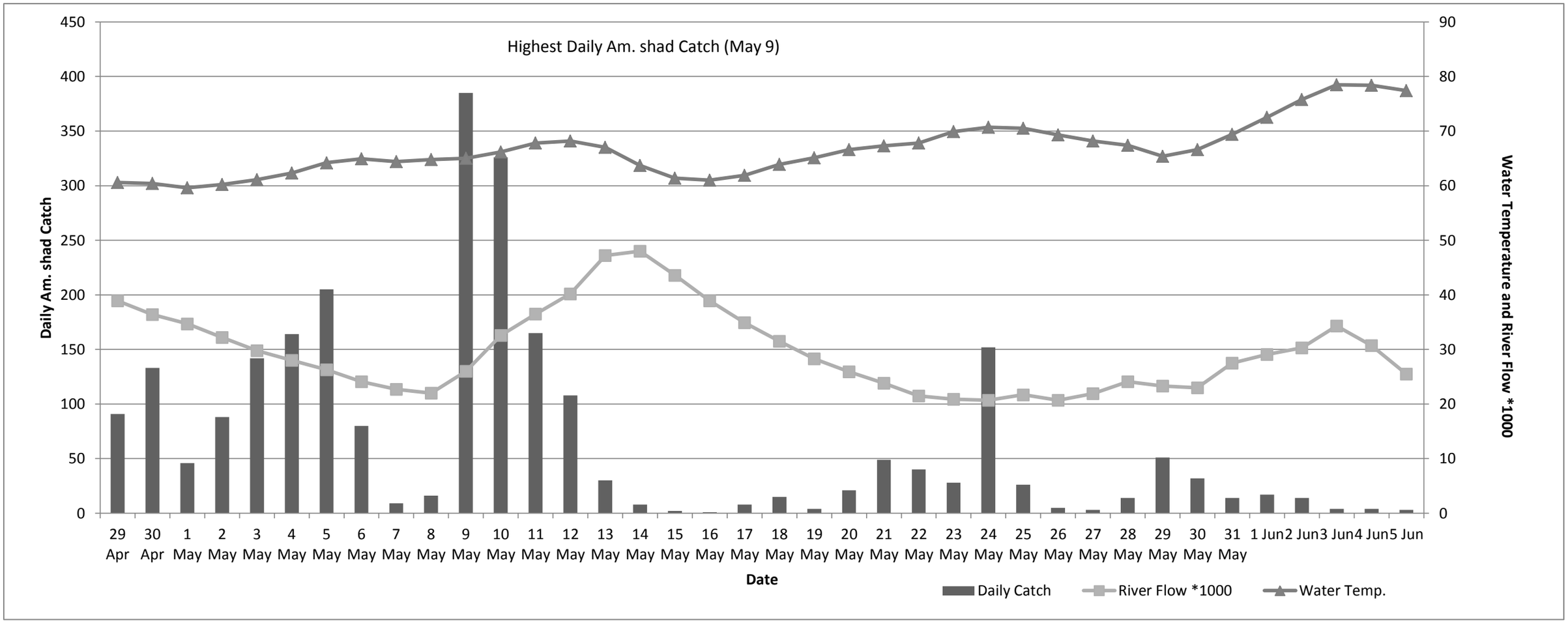

Figure 1

A plot of river flow (USGS Marietta Guage) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2013.

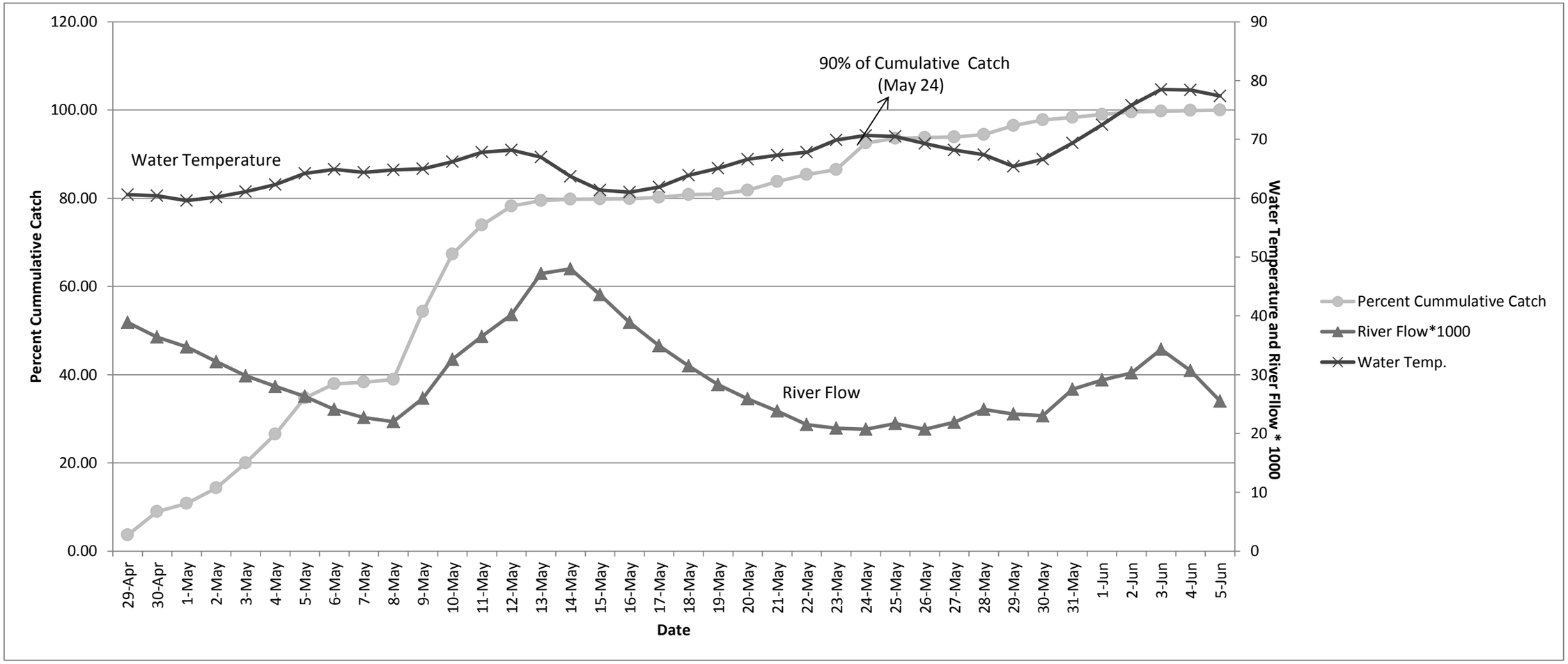

Figure 2

A plot of river flow (USGS Marietta Guage) and water temperature (°F) in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2013.