3.0 JOB 1, PART 3: SUMMARY OF OPERATIONS AT THE HOLTWOOD DAM FISH PASSAGE FACILITY, 2009

Normandeau Associates Inc.
1921 River Road
Drumore, Pennsylvania 17518

3.1 EXECUTIVE SUMMARY

Fishway operations at Holtwood Dam began on 3 May, 2009. The tailrace lift was operated for 36 days while the spillway lift operated on 19 days. Lift operations were terminated for the season, with agency concurrence, on 7 June. Both the tailrace and spillway lifts operated with minimal maintenance issues during the passage season, resulting in no lost fishing time. The 2009 fish passage season marks the thirteenth year of operation at Holtwood.

The lifts passed 254,667 fish of 25 taxa plus one hybrid, (tiger muskie). Gizzard and American shad, walleye, and quillback dominated the catch, and comprised nearly 98% of the total fish collected and passed. American shad and one alewife (residualized) represented the Alosa species collected and passed at Holtwood in 2009.

A total of 10,253 American shad (94% of total shad catch) were passed in the tailrace lift while the spillway lift accounted for 643 American shad (6% of total shad catch). Collection and passage of shad varied daily with 90% of total shad (9,860) passed prior to 28 May. The highest daily shad catch occurred on 17 May when 1,315 shad moved upstream during 11.1 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 0900 hrs and 1159 hrs and again between 1500 hrs and 1659 hrs.

Fishway operations were conducted at water temperatures ranging from 60.8°F to 74.1°F and river flows between 24,800 and 63,300 cfs. Spillage occurred on 23 of the 36 days of operation, (nearly 64% of the season). River water temperatures were relatively stable but river flows fluctuated throughout the passage season. American shad of advanced or post-spawned condition were observed during fish passage operations from late-May to the end of 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 2009 was 21, all orange floy tags from this year's (2009 Hook & Line) tagging effort.

The 2009 American shad passage rate at Holtwood versus Conowingo (37.2% of fish passing Conowingo passed Holtwood) was above the historical average of 32% (1997-2008).

A low, stable, river flow appears to be critical for enhancing shad passage rates. We documented 82% of American shad passed at river flows less than 40,000 cfs, with 17% passing at river flows greater than 40,000 cfs but less than 60,000 cfs. It should be noted that river flows during the 2008 and 2009 passage seasons were similar, but shad passage improved in 2009, which

could be the result of flashboard integrity this season. In 2009, favorable river flows allowed flashboard repairs to be completed prior to the fish passage season, and the boards remained intact through the entire season. This helped maintain forebay water levels and provided an ample volume of water to feed the entire fish lift water supply system and allowed for the simultaneous operation of the tailrace and spillway fish lifts. Future operations of the fishway will build on the past thirteen years of operation experience.

3.2 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 2009. This year marked the thirteenth operational season.

Objectives of 2009 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.

3.3 HOLTWOOD OPERATION

3.3.1 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, operation of four rubber dams installed as part of the fishway project, and operation of the Safe Harbor Hydroelectric Station.

In spring 2009, rubber dams 2 and 3 were inoperable (not inflated) due to irreparable damage that occurred in March and April of 2007. Rubber dam 4 was also inoperable having been removed from service in November 2008 due to damage similar to the cause of failure of rubber dams 2 and 3. Wooden flashboards have been installed in place of these rubber dam sections. Flashboard repairs were conducted prior to fish lift start-up operations on 30 April, and 1 and 2 May 2009. The passage of over one-thousand shad at Conowingo Dam on 28 April triggered the start of fish lift operations on 3 May at Holtwood Dam. Due to river flows greater than station

capacity, spill occurred during 23 of the 36 days of fish lift operation, (Table 2). Flashboard repair occurred again on 27 May to reduce water leakage through the flashboards. Passage operations ended on 7 June, with agency concurrence, due to 9 straight days of poor American shad passage, (less than 40 shad per day), and a lack of pre-spawned shad available for passage.

3.4 FISHWAY DESIGN AND OPERATION

3.4.1 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 in, through, and from the lifts 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, are an integral component of effective spillway lift operation. During fish lift operations in 2009, only one of the four rubber crest dams was operational and flashboards were installed upstream of the three damaged rubber dams to maintain forebay water levels.

Design guidelines for fishway operation include four entrance combinations. These are: (1) entrance A, B, and C; (2) entrance A and B; (3) entrance A and C; and (4) Entrance C. 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 2009, the following gate combinations were utilized: Entrances A, B, and C (9 days); Entrances A and C (10 days); Entrances A and B (9 days); and Entrance A only (8 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 or rubber dams are deflated because spillage may mask or interfere with the attraction flow from the spillway entrance gate.

3.4.2 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 catch of shad at Conowingo Dam triggered the start of Holtwood operations on 3 May, after completion of flashboard repairs. This year we recorded 36 straight days of operation. The tailrace lift was operated everyday during this year's fish passage operation and encountered only minor mechanical problems which were quickly resolved. The spillway lift was operated on 19 days this season and also encountered only minor mechanical problems which were quickly resolved as well.

The 2009 American shad passage rate at Holtwood versus Conowingo (37.2% of fish passing Conowingo passed Holtwood) was above the historical average of 32% (1997-2008). Although this passage rate is below desired passage values, it is a marked improvement compared to passage in 2008, which had the same number of days, (20), when river flow was less than 40,000 cfs. More American shad were also passed when river flows ranged between 40,000 and 60,000 cfs in 2009 as compared to 2008 (Table 5). 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 lifts 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).

3.4.3 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 co-operators.

3.5 RESULTS

3.5.1 Relative Abundance

The diversity and abundance of fishes collected and passed in the Holtwood fishway during the spring 2009 operational period is presented in Table 1. A total of 254,667 fish of 25 taxa plus one hybrid passed upstream into Lake Aldred. Gizzard shad (228,712), American shad (10,896), walleye (6,570), and quillback (3,269) comprised nearly 98% of the fishes passed. The 2009 American shad passage total was the fifth lowest observed based on actual numbers of fish, but based on Conowingo results, this was the sixth highest passage percentage rate recorded in the thirteen years of fish lift operations at Holtwood, although the operation season was the third shortest (Tables 1, 5, and 6). Other abundant fishes passed included comely shiner (2,270), shorthead redhorse (1,497), channel catfish (737), and smallmouth bass (381). The peak one-day passage of all species occurred on 3 May, (first day of operation) when 34,618 fish were passed, comprised mostly of gizzard shad (32,217), American shad (1,003), and walleye (801).

For 61% of the season, (22 days), water clarity ranged from 20 to 28 inches of visibility, allowing the viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at Holtwood in 2009 was low, (21orange tags), all from this season's tagging efforts and accounted for 20% of the 2009 orange floy tags observed at the Conowingo East Lift viewing room.

3.5.2 American Shad Passage

A total of 10,896 American shad were passed at Holtwood during 2009; 10,253 American shad passed in the tailrace lift while the spillway lift accounted for 643 American shad (Table 4). Collection and passage of shad varied daily with 90% of total shad (9,860) passed prior to 28 May. The highest daily shad catch occurred on 17 May when 1,315 shad moved upstream during 11.1 hours of operation. On a daily basis, overall shad passage was strongest through the fishway between 0900 hrs and 1159 hrs and again between 1500 hrs and 1659 hrs (Table 3). Fishway operations were conducted at water temperatures ranging from 60.8°F to 74.1°F and river flows between 24,800 and 63,300 cfs, (Table 2). Spillage occurred on 23 of the 36 days of operation, (nearly 64% of the season). River water temperatures were relatively stable but river flows fluctuated throughout the passage season. American shad of advanced or post-spawned condition were observed during fish passage operations from late-May to the end of season.

The capture of shad at the fishway occurred over a relatively narrow range of station operation and discharge conditions (Table 2) and were somewhat similar to conditions observed in 2008. Shad were attracted to the tailrace lift at water elevations ranging from 113 ft. to 119 ft., (a tailrace elevation of 119 ft. occurred on 31of the 36 days of operation). Tailrace elevations correspond to unit operation, which varies from 0 to 10 units. During spring 2009, tailrace fishway operation generally coincided with a ten turbine operation/generation scenario due to consistent river flows greater than station capacity. Spillway lift operation usually occurs 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 year because the flashboards were intact during the entire fish passage season.

Passage of shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 164 ft to 172.5ft (Table 2). Forebay elevations during passage operations generally ranged between 169ft to 171ft. in 2009.

The hourly passage numbers of American shad at Holtwood are provided in Table 3. Nearly 55% (5,976 American shad) passed through the fishway between 2 distinct time periods, (0900 to

1159 hrs and 1500 to 1659 hrs). Generally, shad passage was consistent from 0900 hrs to 1759 hrs, then gradually 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 nineteen 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, 10,253 and 643 shad were captured in the tailrace and spillway lifts over the total operating period in 2009, respectively (Table 4).

3.5.3 Passage Evaluation

In spring 2009, 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 2009, spill events occurred during 23 of the 36 days of fishway operation. We documented 82% of American shad passed at river flows less than 40,000 cfs, with 17% passing at river flows greater than 40,000 cfs but less than 60,000 cfs, (Table 5 and Figure 2). During fish lift operations in 2009, river flows ranged from 24,800 cfs to 63,300 cfs. The 2009 American shad passage rate at Holtwood versus Conowingo (37.2% of American shad passed at Conowingo were passed by Holtwood), was above the historical average of 32% observed at Holtwood from 1997 to 2008. In 2009, favorable river flows allowed flashboard repairs to be conducted prior to the fish passage season, and the boards remained intact throughout the entire season, which helped maintain forebay water levels that provided an ample volume of water to feed the entire fish lift water supply system and allowed for the simultaneous operation of the tailrace and spillway fish lifts.

We hope to optimize future fishway operations by utilizing knowledge gained through these thirteen 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 7shad mortalities, less than 0.01% of total American shad passage.

3.6 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.

3.7 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.

3.8 TABLES AND FIGURES

Table 1: Summary of the daily number of fish passed by the Holtwood fish passage facility in 2009.

Date:	*3 May*	*4 May*	*5 May*	*6 May*	*7 May*	*8 May*	*9 May*	*10 May*	*11 May*	*12 May*
Hours of Operation - Tailrace:	*9.8*	*9.8*	*9.0*	*7.5*	*9.0*	*9.5*	*9.5*	*9.2*	*9.8*	*9.1*
Number of Lifts - Tailrace:	*22*	*21*	*16*	*12*	*12*	*12*	*12*	*14*	*16*	*12*
Hours of Operation - Spillway:	*0.0*	*0.0*	*0.0*	*3.9*	*0.0*	*0.0*	*0.0*	*0.0*	*7.3*	*0.0*
Number of Lifts - Spillway:	*0*	*0*	*0*	*6*	*0*	*0*	*0*	*0*	*7*	*0*
Water Temperature (°F):	*65.2*	*64.5*	*63.6*	*62.1*	*60.4*	*60.7*	*61.4*	*64.1*	*64.5*	*63.8*
American shad	1,003	1,288	352	267	79	162	69	134	298	67
Alewife (residualized)	0	0	0	0	0	0	0	0	0	0
Gizzard shad	32,217	7,225	11,897	8,099	4,477	5,448	6,663	9,878	10,586	5,114
Sea lamprey	0	0	0	0	0	0	1	0	1	0
Rainbow trout	0	0	0	0	0	0	0	0	0	0
Brown trout	0	0	3	2	0	1	0	0	0	0
Muskellunge	1	1	0	0	0	0	0	0	0	0
Tiger muskie	0	0	0	0	0	0	0	0	0	0
Carp	18	2	2	7	2	2	9	7	18	0
Quillback	90	41	10	2,529	3	0	0	4	7	4
Shorthead redhorse	281	200	257	332	33	29	5	23	52	15
Yellow bullhead	0	0	0	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0	0	0	0
Channel catfish	3	1	4	18	12	11	47	17	20	0
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	6	1	0	7	0	1	2	2	2	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
Bluegill	2	1	0	0	0	0	1	0	0	0
Smallmouth bass	196	14	23	8	5	16	14	14	13	3
Largemouth bass	0	0	0	0	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	1	0	0
Yellow perch	0	0	0	1	1	1	0	0	0	0
Walleye	801	500	547	172	144	108	74	113	221	68
Comely shiner	0	0	0	0	0	0	0	0	0	0
Total	***34,618***	***9,274***	***13,095***	***11,442***	***4,756***	***5,779***	***6,885***	***10,193***	***11,218***	***5,271***

Table 1: Summary of the daily number of fish passed by the Holtwood fish passage facility in 2009 (continued).

Date:	*13 May*	*14 May*	*15 May*	*16 May*	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*
Hours of Operation - Tailrace:	*9.4*	*9.4*	*10.4*	*10.6*	*11.1*	*10.4*	*7.8*	*8.3*	*8.4*	*8.5*
Number of Lifts - Tailrace:	*14*	*12*	*18*	*18*	*21*	*17*	*13*	*14*	*14*	*14*
Hours of Operation - Spillway:	*9.0*	*9.4*	*7.9*	*10.1*	*3.8*	*0.0*	*0.0*	*0.0*	*3.4*	*8.3*
Number of Lifts - Spillway:	*14*	*12*	*9*	*17*	*5*	*0*	*0*	*0*	*4*	*9*
Water Temperature (°F):	*63.2*	*63.3*	*64.2*	*65.6*	*66.9*	*67.0*	*65.7*	*64.4*	*66.0*	*67.1*
American shad	237	61	544	602	1,315	413	115	27	56	93
Alewife (residualized)	0	0	0	0	0	0	0	0	0	0
Gizzard shad	10,299	5,968	11,342	14,496	13,004	7,684	5,491	2,554	3,335	6,935
Sea lamprey	2	1	0	4	1	1	2	0	0	2
Rainbow trout	2	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	1	0	0	0	0	1
Tiger muskie	0	0	0	0	0	0	0	0	0	0
Carp	4	2	0	35	3	0	0	0	4	12
Quillback	0	3	1	83	11	4	50	2	0	1
Shorthead redhorse	42	15	44	85	18	9	1	0	10	12
Yellow bullhead	2	0	0	0	0	0	0	0	0	0
Brown bullhead	8	0	0	0	0	0	0	0	0	0
Channel catfish	5	7	6	32	53	0	8	62	5	6
Flathead catfish	0	0	0	0	0	0	0	0	0	0
Rock bass	3	0	0	4	2	0	0	2	0	0
Redbreast sunfish	0	0	0	0	0	0	0	0	0	1
Green sunfish	0	0	0	0	0	1	0	0	0	0
Bluegill	2	1	0	5	6	0	0	0	1	0
Smallmouth bass	6	6	13	11	10	6	0	1	0	6
Largemouth bass	0	0	0	0	0	2	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	1
Yellow perch	0	0	0	0	0	0	0	0	0	0
Walleye	241	234	200	347	253	217	61	280	71	233
Comely shiner	0	0	0	0	0	0	0	0	0	0
Total	***10,856***	***6,298***	***12,150***	***15,704***	***14,677***	***8,337***	***5,728***	***2,928***	***3,482***	***7,303***

Table 1: Summary of the daily number of fish passed by the Holtwood fish passage facility in 2009 (continued).

Date:	*23 May*	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*	*31 May*	*1 Jun*
Hours of Operation - Tailrace:	*10.4*	*11.6*	*9.5*	*9.5*	*8.4*	*10.1*	*8.4*	*8.4*	*8.0*	*7.6*
Number of Lifts - Tailrace:	*16*	*19*	*18*	*15*	*17*	*17*	*15*	*13*	*12*	*11*
Hours of Operation - Spillway:	*10.3*	*8.8*	*5.8*	*8.8*	*0.0*	*8.4*	*3.6*	*0.0*	*0.0*	*0.0*
Number of Lifts - Spillway:	*12*	*8*	*7*	*9*	*0*	*8*	*4*	*0*	*0*	*0*
Water Temperature (°F):	*69.1*	*70.0*	*72.9*	*74.0*	*73.2*	*72.8*	*71.0*	*68.0*	*68.1*	*67.7*
American shad	378	685	1,010	223	382	710	197	32	24	6
Alewife (residualized)	0	0	0	0	0	0	0	0	0	0
Gizzard shad	10,155	8,711	6,558	6,067	764	4,562	2,395	520	446	157
Sea lamprey	0	1	0	0	0	1	0	0	0	0
Rainbow trout	0	0	0	0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0	0	1	0	0
Muskellunge	0	0	0	0	0	1	0	0	0	0
Tiger muskie	0	1	0	0	0	0	0	0	0	0
Carp	5	7	12	8	4	10	2	1	1	0
Quillback	3	4	13	252	68	50	24	7	1	0
Shorthead redhorse	5	9	5	7	0	0	3	2	0	0
Yellow bullhead	0	0	0	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0	0	0	0
Channel catfish	26	43	0	0	0	5	25	75	69	10
Flathead catfish	0	0	0	0	0	0	0	0	1	0
Rock bass	2	7	0	0	1	0	0	2	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
Bluegill	4	0	0	0	0	0	0	4	2	0
Smallmouth bass	2	2	1	0	0	6	1	0	1	1
Largemouth bass	1	0	0	0	0	0	0	0	0	0
White crappie	0	1	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	0	0	0	0	0	1	0
Walleye	227	290	219	263	11	215	92	33	33	4
Comely shiner	0	0	0	0	2,270	0	0	0	0	0
Total	***10,808***	***9,761***	***7,818***	***6,820***	***3,500***	***5,560***	***2,739***	***677***	***579***	***178***

Table 1: Summary of the daily number of fish passed by the Holtwood fish passage facility in 2009 (continued).

Date:	*2 Jun*	*3 Jun*	*4 Jun*	*5 Jun*	*6 Jun*	*7 Jun*	***TOTAL***
Hours of Operation - Tailrace:	*7.8*	*8.2*	*6.8*	*7.4*	*8.2*	*7.1*	***323.9***
Number of Lifts - Tailrace:	*10*	*12*	*9*	*10*	*10*	*10*	***518.0***
Hours of Operation - Spillway:	*6.3*	*7.7*	*6.7*	*7.2*	*0.0*	*0.0*	***136.7***
Number of Lifts - Spillway:	*6*	*8*	*6*	*6*	*0*	*0*	***157.0***
Water Temperature (°F):	*68.6*	*69.2*	*69.9*	*70.0*	*68.1*	*66.6*	
American shad	11	14	4	26	8	4	**10,896**
Alewife (residualized)	0	0	0	0	0	1	**1**
Gizzard shad	578	781	239	1,345	2,380	342	**228,712**
Sea lamprey	0	0	0	0	0	0	**17**
Rainbow trout	0	0	1	0	0	0	**3**
Brown trout	0	1	0	1	0	0	**12**
Muskellunge	0	0	0	0	0	0	**5**
Tiger muskie	0	0	0	0	0	0	**1**
Carp	1	2	0	0	0	1	**181**
Quillback	0	1	0	2	1	0	**3,269**
Shorthead redhorse	0	1	0	0	1	1	**1,497**
Yellow bullhead	0	0	0	0	0	0	**2**
Brown bullhead	0	0	0	0	0	0	**8**
Channel catfish	22	31	12	67	22	13	**737**
Flathead catfish	0	0	0	0	0	1	**2**
Rock bass	0	0	0	0	0	1	**45**
Redbreast sunfish	0	0	0	0	0	0	**1**
Green sunfish	0	0	0	0	0	0	**1**
Bluegill	0	10	1	4	2	0	**46**
Smallmouth bass	1	0	1	0	0	0	**381**
Largemouth bass	0	0	0	0	0	0	**3**
White crappie	0	0	0	0	0	0	**1**
Black crappie	0	0	0	0	0	0	**2**
Yellow perch	0	0	0	0	0	0	**4**
Walleye	57	41	39	94	36	31	**6,570**
Comely shiner	0	0	0	0	0	0	**2,270**
Total	***670***	***882***	***297***	***1,539***	***2,450***	***395***	**254,667**

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 2009.

	River Flow	Ave.Water	Secchi	Number	Weir Gate Operation			Elevation (ft)		
Date	(cfs)	Temp. (°F)	(in)	of Units	A	B	C*	Tailrace	Spillway	Forebay
3 May	27,400	65.16	20	10	X	X		119	Leakage	169
4 May	30,100	64.30	20	10	X			118	Leakage	167
5 May	37,400	63.28	24	10	X	X		119	Spill	170
6 May	46,700	62.06	22	10	X		X	119	Spill	171
7 May	62,600	60.77	18	10	X			119	Spill	172
8 May	52,400	61.20	20	10	X			119	Spill	171
9 May	48,500	62.12	16	10	X	X		119	Spill	171
10 May	44,300	64.15	20	10	X			119	Spill	171
11 May	42,300	64.48	22	10	X		X	119	Spill	170
12 May	40,900	63.78	22	10	X			119	Spill	170
13 May	35,300	63.26	24	10	X		X	118	Leakage	168.5
14 May	34,400	63.29	24	10	X		X	119	Leakage	168
15 May	35,600	64.42	26	10	X		X	119	Leakage	170
16 May	35,600	65.82	26	10	X		X	119	Leakage	169
17 May	37,900	66.83	26	10	X		X	119	Leakage	168
18 May	43,200	67.17	26	10	X	X		119	Spill	171
19 May	54,800	66.11	16	10	X	X		119	Spill	171
20 May	54,400	65.62	14	10	X	X		119	Spill	172
21 May	47,500	66.46	14	10	X	X	X	119	Spill	171
22 May	39,900	67.63	22	10	X	X	X	119	Spill	170
23 May	34,200	69.63	24	10	X	X	X	119	Leakage	170
24 May	30,300	71.17	24	10	X	X	X	119	Leakage	169
25 May	28,800	73.19	24	10	X	X	X	118	Leakage	168
26 May	25,900	74.14	24	10	X	X	X	119	Leakage	169
27 May	25,200	73.31	28	10	X			113	116	164
28 May	24,800	72.76	28	10	X	X	X	117	116	169

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 2009 (continued).

	River Flow	Ave. Water	Secchi	Number	Weir Gate Operation			Elevation (ft)		
Date	(cfs)	Temp. (°F)	(in)	of Units	A	B	C	Tailrace	Spillway	Forebay
29 May	41,800	70.55	22	10	X		X	119	Spill	171
30 May	63,300	68.32	16	10	X	X		119	Spill	172.5
31 May	54,900	68.55	8	10	X	X		119	Spill	172
1 Jun	48,700	68.21	12	10	X			119	Spill	171
2 Jun	42,400	68.61	12	10	X		X	119	Spill	170.5
3 Jun	38,400	69.27	12	10	X		X	119	Spill	170
4 Jun	37,700	69.92	14	10	X	X	X	119	Spill	170
5 Jun	35,800	69.67	14	10	X	X	X	119	Spill	170
6 Jun	37,900	68.02	16	10	X	X		119	Spill	171
7 Jun	32,000	67.08	16	10	X			119	Spill	170

* Spillway entrance gate C damaged by flooding prior to 2005 season.

Table 3: Hourly summary of American shad passage at the Holtwood fish passage facility in 2009.

Date:	*3 May*	*4 May*	*5 May*	*6 May*	*7 May*	*8 May*	*9 May*
Observation Time (Start):	*9:00*	*8:45*	*8:30*	*10:30*	*8:15*	*8:00*	*8:05*
Observation Time (End):	*19:00*	*19:00*	*18:00*	*18:30*	*17:30*	*18:00*	*18:00*
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	--	1	1	--	0	24	10
0900 to 0959	66	227	11	--	11	6	4
1000 to 1059	112	243	4	0	1	5	1
1100 to 1159	136	228	10	57	1	9	0
1200 to 1259	97	110	5	37	6	6	1
1300 to 1359	79	52	13	40	4	12	4
1400 to 1459	76	71	68	48	4	7	11
1500 to 1559	96	76	124	28	20	31	8
1600 to 1659	100	135	43	37	22	48	17
1700 to 1759	122	83	73	15	10	14	13
1800 to 1859	119	62	--	5	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	**1,003**	**1,288**	**352**	**267**	**79**	**162**	**69**

Date:	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*	*16 May*
Observation Time (Start):	*8:15*	*8:20*	*8:20*	*8:00*	*8:15*	*8:10*	*7:45*
Observation Time (End):	*18:00*	*18:30*	*17:40*	*17:45*	*17:45*	*18:45*	*18:40*
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	0
0800 to 0859	6	5	3	4	1	7	74
0900 to 0959	16	38	18	32	2	25	80
1000 to 1059	18	23	11	27	5	47	60
1100 to 1159	9	43	5	31	3	35	35
1200 to 1259	11	23	8	48	10	21	50
1300 to 1359	4	29	6	36	13	47	53
1400 to 1459	5	41	4	23	8	93	46
1500 to 1559	25	33	6	16	2	57	31
1600 to 1659	22	23	5	14	10	110	70
1700 to 1759	18	28	1	6	7	85	40
1800 to 1859	--	12	--	--	--	17	63
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	**134**	**298**	**67**	**237**	**61**	**544**	**602**

Table 3: Hourly summary of American shad passage at the Holtwood fish passage facility in 2009 (continued).

Date:	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*
Observation Time (Start):	*7:50*	*8:05*	*8:20*	*8:05*	*8:15*	*8:20*	*8:00*
Observation Time (End):	*19:11*	*18:30*	*16:30*	*16:35*	*16:30*	*16:45*	*18:30*
Military Time (hrs)							
0700 to 0759	0	--	--	--	--	--	--
0800 to 0859	147	52	1	0	3	12	7
0900 to 0959	156	54	55	4	8	17	61
1000 to 1059	122	43	14	4	4	16	58
1100 to 1159	111	41	20	5	4	10	34
1200 to 1259	136	10	5	4	3	8	42
1300 to 1359	103	28	5	2	6	14	24
1400 to 1459	68	34	6	1	11	8	18
1500 to 1559	88	32	7	7	9	4	22
1600 to 1659	106	70	2	0	8	4	51
1700 to 1759	142	35	--	--	--	--	50
1800 to 1859	99	14	--	--	--	--	11
1900 to 1959	37	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	**1,315**	**413**	**115**	**27**	**56**	**93**	**378**

Date:	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*
Observation Time (Start):	*8:00*	*8:55*	*8:10*	*8:00*	*8:15*	*8:46*	*8:00*
Observation Time (End):	*19:00*	*18:40*	*17:50*	*16:50*	*18:25*	*17:30*	*17:00*
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	46	146	40	0	58	7	4
0900 to 0959	26	190	31	97	36	19	3
1000 to 1059	30	115	33	39	112	41	0
1100 to 1159	73	140	30	33	130	25	2
1200 to 1259	64	101	14	41	59	22	4
1300 to 1359	87	41	13	80	72	20	5
1400 to 1459	50	67	16	29	70	15	5
1500 to 1559	63	116	15	24	70	21	5
1600 to 1659	87	25	14	39	39	22	4
1700 to 1759	89	69	17	--	49	5	--
1800 to 1859	70	--	--	--	15	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	**685**	**1,010**	**223**	**382**	**710**	**197**	**32**

Table 3: Hourly summary of American shad passage at the Holtwood fish passage facility in 2009 (continued).

Date:	*31 May*	*1 Jun*	*2 Jun*	*3 Jun*	*4 Jun*	*5 Jun*	*6 Jun*
Observation Time (Start):	*8:00*	*8:20*	*8:15*	*8:00*	*8:20*	*8:45*	*8:00*
Observation Time (End):	*16:00*	*16:20*	*16:15*	*16:20*	*15:20*	*16:25*	*16:30*
Military Time (hrs)							
0700 to 0759	--	--	--	--	--	--	--
0800 to 0859	0	0	0	1	0	0	0
0900 to 0959	9	2	7	2	3	0	0
1000 to 1059	6	0	1	0	0	17	0
1100 to 1159	6	1	1	2	0	7	0
1200 to 1259	0	1	1	2	1	1	1
1300 to 1359	2	2	1	1	0	0	1
1400 to 1459	1	0	0	4	0	1	1
1500 to 1559	0	0	0	1	0	0	2
1600 to 1659	--	0	0	1	--	0	3
1700 to 1759	--	--	--	--	--	--	--
1800 to 1859	--	--	--	--	--	--	--
1900 to 1959	--	--	--	--	--	--	--
2000 to 2059	--	--	--	--	--	--	--
Total	**24**	**6**	**11**	**14**	**4**	**26**	**8**

Date:	*7 Jun*	
Observation Time (Start):	*8:20*	
Observation Time (End):	*16:00*	***Total***
Military Time (hrs)		
0700 to 0759	--	0
0800 to 0859	0	660
0900 to 0959	0	1316
1000 to 1059	1	1213
1100 to 1159	0	1277
1200 to 1259	1	954
1300 to 1359	1	900
1400 to 1459	1	911
1500 to 1559	0	1039
1600 to 1659	--	1131
1700 to 1759	--	971
1800 to 1859	--	487
1900 to 1959	--	37
2000 to 2059	--	0
Total	**4**	**10,896**

Table 4: Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2009.

	Shad	Number Collected		Percent Collected	
Date	Catch	Tailrace	Spillway*	Tailrace	Spillway
3-May	1,003	1,003	--	100%	--
4-May	1,288	1,288	--	100%	--
5-May	352	352	--	100%	--
6-May	267	266	1	100%	0%
7-May	79	79	--	100%	--
8-May	162	162	--	100%	--
9-May	69	69	--	100%	--
10-May	134	134	--	100%	--
11-May	298	297	1	100%	0%
12-May	67	67	--	100%	--
13-May	237	37	200	16%	84%
14-May	61	41	20	67%	33%
15-May	544	517	27	95%	5%
16-May	602	512	90	85%	15%
17-May	1,315	1,275	40	97%	3%
18-May	413	413	--	100%	--
19-May	115	115	--	100%	--
20-May	27	27	--	100%	--
21-May	56	56	0	100%	0%
22-May	93	80	13	86%	14%
23-May	378	227	151	60%	40%
24-May	685	680	5	99%	1%
25-May	1,010	960	50	95%	5%
26-May	223	208	15	93%	7%
27-May	382	382	--	100%	--
28-May	710	704	6	99%	1%
29-May	197	197	0	100%	0%
30-May	32	32	--	100%	--
31-May	24	24	--	100%	--
1-Jun	6	6	--	100%	--
2-Jun	11	11	0	100%	0%
3-Jun	14	14	0	100%	0%
4-Jun	4	4	0	100%	0%
5-Jun	26	2	24	8%	92%
6-Jun	8	8	--	100%	--
7-Jun	4	4	--	100%	--
Total	***10,896***	***10,253***	***643***	***94%***	***6%***

* Spillway entrance gate severely damaged by Hurricane Ivan flooding in September, 2004. Operation of Spillway lift during 2009 occurred without the use of a functional entrance gate.

Table 5: Holtwood fishway summary table evaluating American shad passage at three river flow ranges 1997 to 2009.

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*	2005	2006	2007	2008*	2009*
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr	27 Apr	11 Apr	01 May	21 Apr	03 May
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun	10 Jun	06 Jun	04 Jun	09 Jun	07 Jun
Season duration (days)	58	47	40	40	43	55	36	39	45	57	35	50	36
Number of days of operation	55	41	40	36	42	35	34	39	36	57	35	49	36
American shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135	109,360	68,926	56,899	25,464	19,914	29,272
American shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254	3,428	34,189	35,968	10,338	2,795	10,896
River flow ≤40,000 cfs													
Number of days	48	22	34	19	40	19	15	2	33	48	27	20	20
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%	92%	84%	77%	40%	56%
Number of American shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2	34,060	35,302	9,549	2,242	8,939
Daily average of American shad passed	546	341	1,002	1,037	2,733	543	1,348	1	1,032	735	354	112	447
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%	99.6%	98.1%	92.3%	80.2%	82%
River flow 40,001 to 60,000 cfs													
Number of days	7	2	6	12	2	14	18	20	3	5	8	22	14
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.3%	8%	9%	23%	44%	39%
Number of American shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943	129	566	789	533	1,846
Daily average of American shad passed	266	115	106	795	317	502	279	97	43	113	99	24	132
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.8%	56.7%	0.4%	1.6%	7.6%	19.0%	17.0%
River flow >60,000 cfs													
Number of days	0	17	0	5	0	2	1	17	0	4	0	8	2
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.6%	0%	7%	0%	16%	5%
Number of American shad passed	0	493	0	173	0	171	6	1,483	0	100	0	20	111
Daily average of American shad passed	0	29	0	35	0	86	6	87	0	25	0	2	55
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.3%	0.0%	0.3%	0.0%	0.7%	1.0%

* Denotes seasons of high river flow.

Table 6: Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2009.

	Conowingo East	Holtwood		Safe Harbor		York Haven	
		Number	Passed	Number	Passed	Number	Passed
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%	4,675	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%**

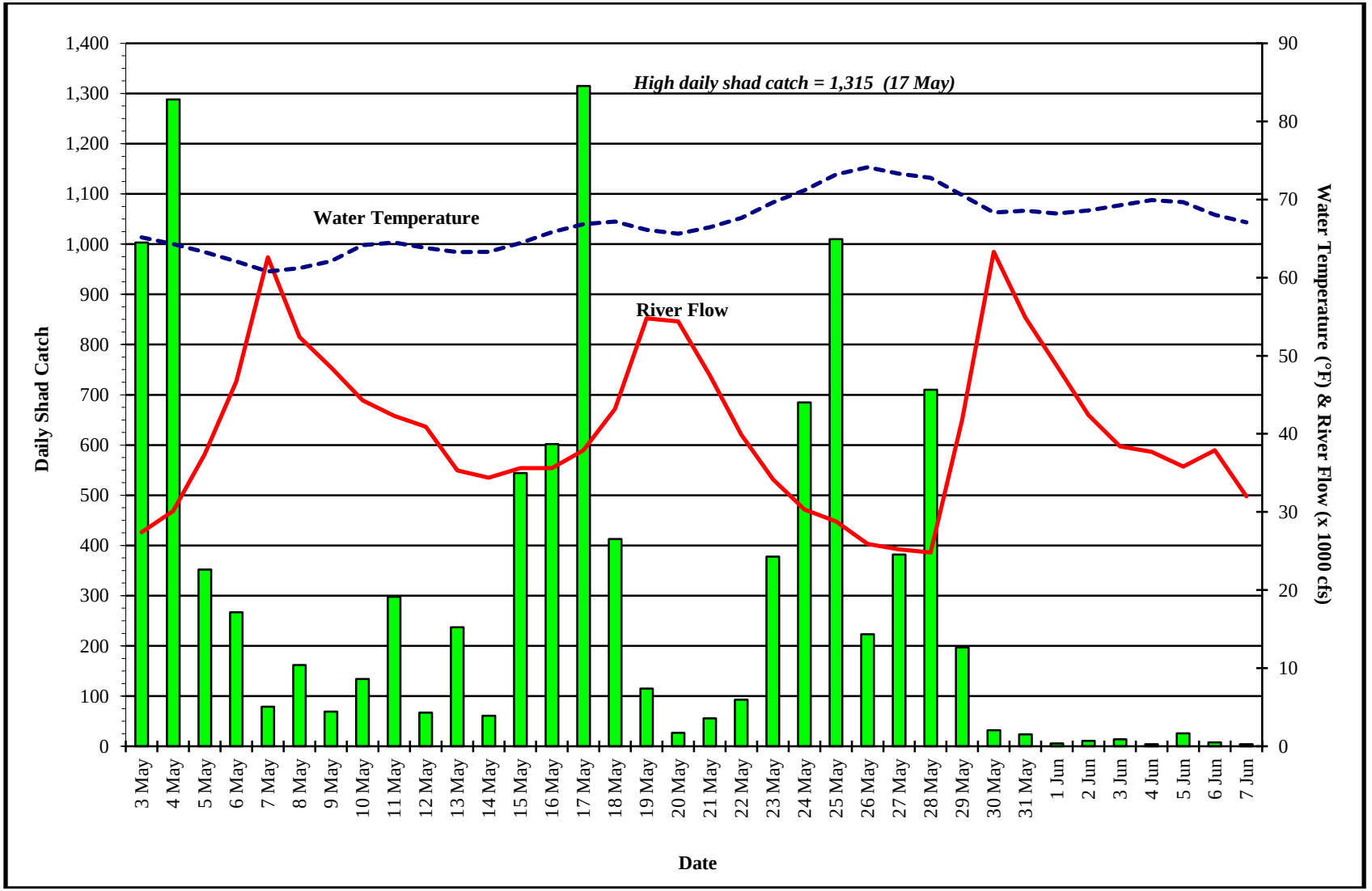

Figure 1: A plot of river flow (x1000) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2009.

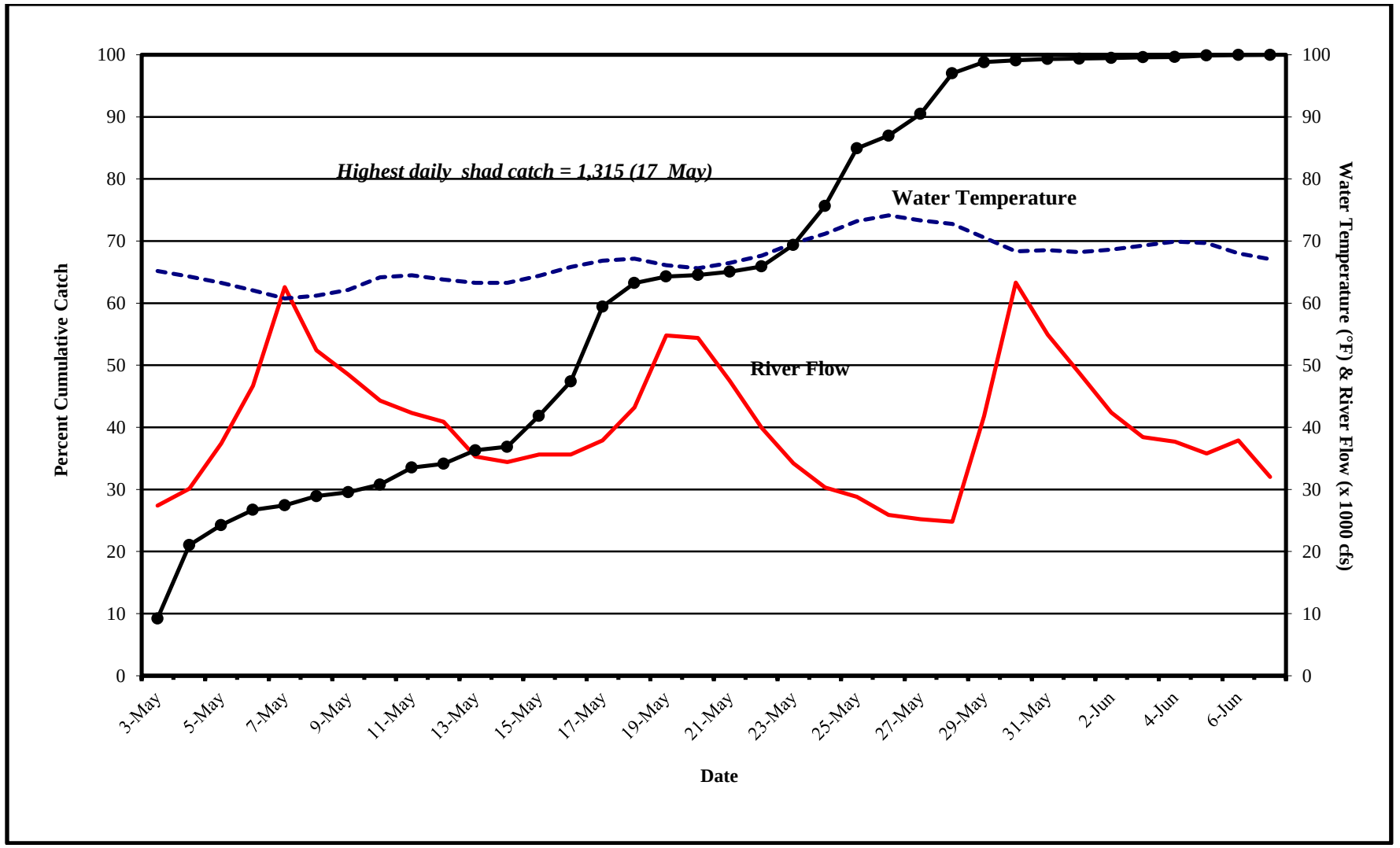

Figure 2: **A plot of river flow (x1000 cfs) and water temperature (°F) in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2009.**