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PEACH BOTTOM ATOMIC POWER STATION

Materials Prepared For The Environmental Protection Agency

316 (b) Demonstration
for PBAPS Units No. 2 & 3
on Conowingo Pond

Prepared By

PHILADELPHIA ELECTRIC COMPANY

June 1977

PEACH BOTTOM ATOMIC POWER STATION

MATERIALS PREPARED FOR THE ENVIRONMENTAL PROTECTION AGENCY

316(b) DEMONSTRATION

FOR

PBAPS Units No. 2 & 3

on Conowingo Pond

PHILADELPHIA ELECTRIC COMPANY

MAY, 1977

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1.0 SUMMARY AND CONCLUSIONS

Studies of the effects of impingement and entrainment on the aquatic biota of Conowingo Pond have been conducted since 1973. Analysis of the data indicate that no significant detrimental effects have occurred in populations of organisms in the Pond between preoperational and postoperational periods of study as the result of the operation of Peach Bottom Atomic Power Station Units No. 2 and 3. The changes which have been observed in the Pond are due to natural causes.

The concentrations of chlorophyll a and percent composition of the common algal groups (greens, blue-green and diatoms) at the intake and discharge of the Peach Bottom Atomic Power Station Units No. 2 and 3 (Peach Bottom) were determined in May through early November 1976 to assess the impact of entrainment on the phytoplankton community in Conowingo Pond. Overall the mean chlorophyll a value at the intake was 1.43 mg/m^3 higher than at the discharge but this difference was not significant. Green algae and/or diatoms were most abundant on all but one sampling date in intake and discharge samples. Blue-green algae were most abundant only on 1 of 13 dates. No significant ($P > 0.05$) differences were observed in the common algal groups composition between the intake and discharge; no shift occurred from one group of algae to another in entrainment. Visual examination of the phytoplankton cells in intake and discharge samples indicated that little or no mechanical damage occurred during passage through Peach Bottom.

The extent of physiological damage to phytoplankton cells is not known. However, chlorophyll a concentrations between the intake and discharge were not significantly different which indicates that physiological impact, if any, may be small.

Results of analysis of covariance on preoperational (1970-1973) and post-operational (1974-1976) chlorophyll a data show that no significant change has occurred between years in the Pond due to the operation of Peach Bottom.

Entrainment of zooplankton was studied at the Peach Bottom Station from 1974 through 1976. The species of zooplankton entrained were similar to those found in Conowingo Pond. Although a large variation in mortality occurred, a significant (P = 0.01) mean mortality of 32% at the discharge was observed. Cladocerans suffered a higher mortality than copepods. No significant differences in mortality were detected between years.

The impact of zooplankton entrainment is minimal and non-detectable in the zooplankton population. A statistical analysis indicated no significant change in zooplankton densities between the preoperational and postoperational periods with the exception of two stations in 1975. These stations were in the lower portion of the Pond, far removed from the influence of Peach Bottom. The decrease in densities is attributed to predation by the gizzard shad.

Studies of the entrainment of fish eggs and larvae indicate that 20 species, including all "representative, important species", are subject to entrainment to a varying degree at Peach Bottom. Few fish eggs are entrained. Larvae of the gizzard shad, carp and quillback (rough fishes) comprised most of the entrained fishes. The greatest densities of larvae were entrained from late May to early July. A 100% mortality rate was assumed for all entrained eggs and larvae to calculate losses of adults. Although extrapolation of entrainment losses indicated that different numbers of adult channel catfish, white crappie, sunfish and walleye would be lost each year as the result of the operation of Peach Bottom these losses are within the compensatory reserve of the population. The primary spawning areas are not affected by entrainment. The impact of entrainment is therefore considered to be minimal.

The number and size of fishes impinged on the vertical traveling screens at Peach Bottom Station were determined from November 1973 through December 1976. At Unit No. 2 a total of 16,859 fish (196.87 kg or 433.11 lb) representing 37 species was impinged in 240 12-hr samples. At Unit No. 3, 42,088 fish (1172.95 kg or 2580.48 lb) representing 35 species were impinged in 137 12-hr periods. The channel catfish, white crappie and bluegill were impinged most frequently at both units. Most were less than 120 mm. Impingement was higher in November through April. Most impingement occurred during the start-up phase of each unit. Stepwise multiple regression analysis revealed that the intake water temperature, daily river flow and Pond elevation accounted for most of the variation in the impingement of fishes. However, the variance explained by these variables was not large. The winter (January-March) mortality of white crappie and bluegill at the screens was equivalent to that of about five anglers over the same time period. The impingement losses of such magnitude are insignificant and may not be detectable in the fish populations in a body of water the size of Conowingo Pond. The impingement losses were predicted to be negligible and the field data have confirmed these predictions.

The estimated effects of impingement and entrainment losses will be no different due to the operation of the two additional cooling towers due in service in the summer of 1977, because (1) impingement of fishes is not a function of tower operation and (2) entrainment losses are based on 100% mortality hence are not a function of the number of towers operating.

It is the conclusion of Philadelphia Electric Company that no further impingement and entrainment studies are warranted. In view of the extensive studies conducted to date, either referenced or set forth in this document, it is the view of the Philadelphia Electric Company that ample evidence exists

to support the conclusion that the intake structure at Peach Bottom reflects the best technology available for minimizing adverse environmental effects. This takes into consideration the date of design, construction and completion of the cooling water intake structures.

1.1 INTRODUCTION

This document is prepared in accordance with the "Special Conditions; Environmental Studies" of the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Permit Number Pa. 00097733 issued 31 December and revised 11 April 1977.

The document includes the items discussed at the meeting of personnel from Philadelphia Electric Company (PECO), Pennsylvania Department of Environmental Resources and Ichthyological Associates, Inc. (IA) at Hershey, Pennsylvania on 28 April 1976, and in a subsequent letter of 19 May 1976 from Mr. H. Ronald Preston, EPA, Wheeling Office to Mr. Walter E. Rosengarten, Jr., Environmental Engineering Section, PECO. The following is a verbatim copy of portion of the letter addressing the Peach Bottom Station:

> "On April 28, 1976, a meeting was held at the Hershey Motor Lodge in Hershey, Pennsylvania to discuss 316(b) requirements at nine Philadelphia Electric Company power generating stations. Representatives from Philadelphia Electric, Ichthyological Associates, the Pennsylvania DER, and the U.S. EPA were in attendance (see the attached list for those in attendance). The following items were discussed at the meeting:
>
> 1. <u>Peach Bottom Atomic Power Station, Susquehanna River:</u>
>
> We discussed the impingement program and frequency that had been conducted during 1973-75 for the Nuclear Regulatory Commission and it appears to be satisfactory to meet the 316(b) program. The entrainment program appeared satisfactory except for three areas: (1) Data was not collected on zooplankton during the period of chlorination on units 2 & 3. Ichthyological Associates did not assume 100% mortality on the entrained zooplankton but attempts to show the amount of survival of zooplankton passing through the condensers. Therefore, some sampling during chlorination should be conducted. (2) No phytoplankton studies involving entrainment and its impact have been initiated.

Since phytoplankton plays a major role in the trophic dynamics of Conowingo Pond, it is important that the cooling water impact on this community is evaluated. Such an evaluation may require additional acquisition of data or the impact may be evaluated by examination of peripheral type information. If the latter course is taken, the rationale of doing so should be adequately documented. (3) Current data tabulations do not summarize entrainment data for fish eggs and larvae for unit 3 and for certain months on unit 2. Future proposals should include this information.

It is suggested that the water user address these points in the proposed 316(b) monitoring program and/or in the final impact evaluation of the cooling water intake."

IA, the PECO biological consultant, provided the field studies and analysis for the biological sections of this document. It has conducted a monitoring program of the cooling water intake of the Peach Bottom Atomic Power Station Units No. 2 and 3 (Peach Bottom) since November 1973. The "Operating Environmental Technical Specifications and Bases of the Nuclear Regulatory Commission [NRC] for Peach Bottom Station" required samples of impinged fishes to be taken during four 12-hr periods a week for three months after the full operation of Unit No. 2 which began commercial operation in June 1974. Although the NRC requirements were completed in September 1974, additional impingement sampling has been conducted through December, 1976.

Entrainment sampling was conducted at least twice a month for zooplankton during the peak production period. During the spawning season, fish eggs and larvae were sampled weekly. These studies were conducted through December 1976, although NRC requirements state "studies will be terminated after the first year of Unit No. 3 operation (12 months after commercial operation begins)". Unit No. 3 began commercial operation in December 1974.

At the Hershey meeting, EPA determined that the present impingement sampling frequency and design were satisfactory to obtain data for the 316(b) demonstration evaluation. The sampling design used by IA to determine the impact of the entrainment of fish eggs and larvae and zooplankton was also considered acceptable by the EPA. However, it was suggested that entrainment samples, particularly for zooplankton (designated "representative, important species"), be taken at the time of chlorination and data be obtained on the entrainment of the phytoplankton community. The standing crop of phytoplankton in Conowingo Pond has been monitored since 1970 by measuring the concentrations of total chlorophyll a. Total chlorophyll a had been designated as a "representative, important species" for Conowingo Pond. The entrainment of phytoplankton at Peach Bottom was monitored by sampling total chlorophyll a at the intake and discharge. Because chlorination is not done on a fixed schedule and is unpredictable it was not possible to obtain samples at the time of chlorination.

The designated "representative, important species" of fish are the following: white crappie, channel catfish, bluegill, spotfin shiner, bluntnose minnow, gizzard shad (introduced in 1972), largemouth bass, smallmouth bass and walleye.

In this document the following subjects are discussed: (1) the results of impingement and entrainment studies at the Peach Bottom Station; (2) the relationships between physical factors and impingement; (3) an evaluation of the overall effects of impingement and entrainment on the resident biota, (4) consideration of the present cooling water intake structure as the best available technology for minimizing adverse environmental impact considering the dates of design, construction and completion of the cooling water intake

structure, and (5) intake screen velocity survey by Environmental Devices Corporation, PECO's thermal monitoring consultant (see Appendix C).

In compliance with the NPDES "Special Conditions" requirement, copies of reports submitted to the NRC in fulfillment of Sections 6.1.b "Impingement of Organisms" and 6.1.c "Entrainment of Planktonic Organisms" of the Environmental Technical Specifications for the Peach Bottom Atomic Station Units No. 2 and 3 accompany this document. They include the following: (1) Peach Bottom Atomic Power Station Postoperational Reports 1 through 3 which were sent to the EPA with the 316(a) submittal in July 1975 and (2) Postoperational Reports 4 through 7 enclosed with this 316(b) submittal.

1.2 DESCRIPTION OF STATION

Peach Bottom Atomic Power Station Units No. 2 and 3, operated at PECO, is located on the west shore of Conowingo Pond, a 9,000 acre impoundment on the lower Susquehanna River in southeastern Pennsylvania. Each unit is rated at 1065 megawatt (electrical). Both units have operated at varying loads up to full power.

Cooling water for Units No. 2 and 3 is provided by three 250,000 gpm (557 cfs) pumps per unit, for a total of six pumps with a capacity of 1,500,000 gpm (3350 cfs). The water is drawn directly from Conowingo Pond through an intake structure approximately 500 ft in length and parallel to the Pond (Figure 1.1-1). The intake is protected from heavy debris and ice by 32 sets of vertical steel trash racks. Behind the trash bars are 24 vertical traveling screens of 3/8 in. mesh. The total intake area was designed to be large enough to maintain a maximum velocity through the screens of less than 0.75 fps at the normal Pond level of 108.5 ft (Conowingo Datum). The set of 24 screens (12 for each unit) removes debris from the incoming cooling water before it enters two separate intake ponds which are approximately 3 acres each. A jet water spray dislodges the debris and carries it into a sluiceway. Under normal operating conditions the screens rotate only when a specified pressure gradient is reached across the screens. However, the screens can be washed continuously when large amounts of trash accumulate and in the winter months to eliminate ice. The debris is dewatered as it passes over a vibrating screen at the end of the sluiceway and is collected in a trash bin.

The cooling water enters the intake ponds and travels to the pump intake facility where it is again screened by a 3/8 in. mesh traveling screen before passing through the condensers. During the passage through the condensers

the water temperature is increased up to 21 F at full load. Approximately 60% of the heated water is pumped to three forced draft helper cooling towers. The remainder of the heated water passes directly into a 4700 ft discharge canal where it mixes with the water cooled by the three towers. It is then discharged into Conowingo Pond via a discharge structure. Transit times of the cooling water through the Peach Bottom Station are given in Table 1.1-1.

TABLE 1.1-1

Circulating water transit time through plant cooling system. Data taken from Philadelphia Electric (1975).

Description	Flow directly to discharge canal	Flow through cooling tower system
Retention in intake structure	24.3 min	24.3 min
Circulating water piping to condenser	0.7 min	0.7 min
Condenser	14 sec	14 sec
Condenser to cooling tower pond	1.3 min	1.3 min
First cooling tower pond		24.3 min
Second cooling tower pond		16.3 min
Piping from pond to cooling tower		22 sec
Retention in cooling tower		64 sec
Cooling tower discharge to canal		87.5 sec
Transit in discharge canal	38.9 min	38.9 min
Bypassing of cooling tower, time in discharge canal	22.6 min	
Total	88 min	109 min

2.0 ENTRAINMENT OF ORGANISMS

2.1 PHYTOPLANKTON

A portion of the phytoplankton population found in Conowingo Pond is affected by entrainment from the operation of the Peach Bottom. To determine the effects of entrainment, the phytoplankton biomass and percentage composition of the common algal groups (diatoms, green and blue-green) were compared between samples collected at the intake and discharge. The principal method used to indicate the standing crop of algae in Conowingo Pond has been by measurement of plant pigments, particularly chlorophyll a. Determination of chlorophyll a provides an indirect measure of algal biomass (Richards and Thompson, 1952) and has been used by other investigators to eliminate some of the problems associated with cell counts (Brooks, Smith and Jensen, 1974, Glooschenko and Moore, 1973 and Glooschenko, et al., 1974). A reduction or increase in the concentration of chlorophyll a or a shift in the percent composition of the algal groups at the discharge of Peach Bottom would indicate an effect of entrainment on the phytoplankton community.

2.1.1 Methods

Chlorophyll a concentrations were determined according to Strickland and Parsons (1972) on water samples at the intake (Station 690) and discharge (Station 692) of Peach Bottom on fourteen dates between 17 May and 2 November 1976 (Figure 2.1-1). Percent composition of the algal groups was determined from samples collected for zooplankton entrainment studies. Phytoplankters were counted by units; 1 unit equals 1 cell, 1 filament or 1 colony. The units for each group were summed and percentages calculated. In addition, the overall condition of cells (i.e., broken frustules, disrupted colonies, color and

shape of chloroplasts) was observed. Samples for chlorophyll a analysis and zooplankton were collected on the same day.

2.1.2 Results

Total chlorophyll a values ranged from 1.04 to 58.78 mg/m^3 ($\bar{X}$ = 20.75) at the intake and 1.22 to 52.48 mg/m^3 ($\bar{X}$ = 19.32) at the discharge (Table 2.1-1). Values at the discharge were not consistently lower or higher than those at the intake. Although the mean value at the discharge was 1.43 mg/m^3 lower than that at the intake, the difference for the period sampled was not significant (P = 0.05). These results are similar to findings of other investigators. Fox and Moyer (1973) noted that although chlorophyll a concentrations in phytoplankton passing through the condenser and discharge canal of a fossil fuel-fired plant at Crystal River, Florida varied widely with time of day, no decline in chlorophyll a was detected. Verduin (no date) noted similar results at the Waukegan Nuclear Station. Brooks, Smith and Jensen (1974) found slight changes in chlorophyll a concentrations in the cooling water after passage through the Indian River Station, Delaware. They reported that the slight increase and decrease in concentration may have been related to sampling and analytical variance rather than any definite effect of the power plant. Elier and Delfino (1974) reported no decline in chlorophyll a in the discharge canal during periods of non-chlorination as opposed to periods of chlorination at the Quads Cities Nuclear Station. Beeton and Barker (1974) noted no obvious influence on concentrations of chlorophyll a between the intake and discharge at the Oak Creek Power Plant on Lake Michigan. No significant change in chlorophyll a occurred due to entrainment of phytoplankton at Peach Bottom.

In order to detect the effects, if any, of the operation of Peach Bottom on chlorophyll a in Conowingo Pond, an analysis of covariance was conducted in which the preoperational (1970-1973) and postoperational (1974-1976) means at 11 stations (Figure 2.1-2) were compared after being adjusted for variation due to a control station. The analysis is described by IA (1977a). In addition, a regression model was described from preoperational and postoperational data for January through December to isolate the thermal and/or entrainment effects from those due to natural causes. Results of both analyses indicated that no significant change in chlorophyll a concentrations occurred in the postoperational years due to the operation of Peach Bottom (Tables 2.1-3 and 2.1-4).

2.1.3 Algal Composition

Algal composition, although not a part of the NRC required monitoring program for Peach Bottom, was determined along with chlorophyll a measurements. Three common algal groups in the intake and discharge samples (taken for zooplankton studies) were greens, diatoms and blue-green. Overall, the percent composition revealed that green algae were dominant in both the intake (50.6%) and discharge (53.0%) samples, followed by diatoms (38.9 and 35.4%, respectively) and blue-green algae (9.5 and 11.4%, repsectively) (Table 2.1-2). Although the percent composition of each group varied between the intake and discharge, the differences were slight and not significant ($P = 0.05$).

Bush, et al. (1974) indicated that if light and nutrients are sufficient, a shift from one algal group to another could occur if the temperature change is great enough and the retention time long enough. Although the temperature change (ΔT) ranged from 1 to 20 F during the study (Table 2.1-1), the retention time of water through Peach Bottom was short and no algal

succession was observed in the discharge canal. The common algal group in the intake sample was also the common group in the discharge sample on all dates except 3 August 1976 when diatoms were more abundant in the discharge (Table 2.1-2).

Examination of the phytoplankton cells did not reveal any evidence of visible mechanical damage (i.e., broken frustules, disrupted colonies, discolored chloroplasts, cell membrane separation from cell wall) from entrainment. The number of damaged cells appeared to be similar in both intake and discharge samples. Similar observations have been noted by other investigators such as Patrick (1969), Howell (1969), Verduin (no date) and Brooks, Smith and Jensen (1974). However, physiologic impairment of some phytoplankton may occur, but the extent (if any) is not known.

TABLE 2.1-1

Comparison of total chlorophyll a concentration (mg/m^3) and water temperature at the intake (Station 690) and discharge (Station 692) of the Peach Bottom Station, 17 May-2 November 1976.

Station	Chlorophyll a (mg/m^3) 690 Intake	692 Discharge	Temperature (F) 690	692	ΔT
Date					
17 May	15.37	14.06	67.0	79.0	12.0
27 May	23.62	24.97	63.0	64.0	1.0
15 Jun	24.90	25.56	76.0	91.5	15.5
28 Jun	10.27	9.36	77.0	90.5	13.5
6 Jul	58.78	52.48	77.0	90.5	13.5
28 Jul	32.62	27.92	78.5	87.0	8.5
3 Aug	12.45	12.66	77.0	90.0	13.0
10 Aug	16.41	16.08	76.0	84.0	8.0
17 Aug	32.82	26.82	75.0	88.0	13.0
31 Aug	26.74	23.67	75.0	89.5	14.5
21 Sep	11.02	10.22	71.5	84.5	13.0
6 Oct	20.88	21.14	61.0	77.0	16.0
18 Oct	3.63	4.26	50.0	61.0	11.0
2 Nov	1.04	1.22	44.0	64.0	20.0
Mean	20.75	19.32NS	69.1	81.5	12.4
Min.	1.04	1.22	44.0	61.0	1.0
Max.	58.78	52.48	78.5	91.5	20.0

NS = Nonsignificant, t = 0.28, df = 24

TABLE 2.1-2

Percent composition of the common algal groups found in samples collected at the intake (Station 690) and discharge (Station 692) at the Peach Bottom Station, 17 May-19 October 1976.

Station	Station 690(Intake) Greens (%)	Diatoms (%)	Blue-greens (%)	Station 692(Discharge) Greens (%)	Diatoms (%)	Blue-greens (%)
Date						
17 May	16.7	83.3	0.0	18.4	81.6	0.0
27 May	15.2	83.8	1.0	32.7	66.8	0.5
15 Jun	8.2	31.9	59.9	15.2	19.3	65.4
28 Jun	15.7	83.3	0.0	18.6	78.5	1.6
6 Jul	63.0	31.0	5.9	54.2	21.7	24.1
28 Jul	50.7	9.8	39.4	57.0	9.0	34.0
3 Aug	47.0	47.0	3.0	43.4	52.7	3.9
10 Aug	80.8	17.9	1.3	82.0	16.5	1.5
17 Aug	81.2	12.0	3.6	74.9	18.8	6.3
31 Aug	92.6	6.9	0.5	90.7	9.3	0.0
21 Sep	92.8	5.0	1.9	91.0	5.0	4.0
6 Oct	71.5	25.5	3.0	71.4	21.9	6.7
19 Oct	22.2	68.1	3.9	39.9	59.7	0.3
Mean	50.6	38.9	9.5	53.0 NS[a]	35.4 NS[b]	11.4 NS[c]
Min.	8.2	5.0	0.0	15.2	5.0	0.0
Max.	92.8	83.8	59.9	91.0	81.6	65.4

NS[a] = Nonsignificant, t = 0.21, df = 24
NS[b] = Nonsignificant, t = 0.30, df = 24
NS[c] = Nonsignificant, t = 0.26, df = 24

TABLE 2.1-3

Summary of covariance analysis for total chlorophyll a ($Log_{10}X$ +1) from January-December for preoperational (1970-1973) and postoperational (1974-1976) periods in Conowingo Pond.

Year	1974			1975			1976		
	Postop	Preop	Prob*	Postop	Preop	Prob*	Postop	Preop	Prob*
Station				January-December					
604	1.021	1.028	0.851	0.952	0.984	0.335	0.943	1.007	0.052
605	1.057	1.048	0.736	0.978	1.013	0.111	1.030	1.034	0.885
607	1.082	1.038	0.336	0.954	0.977	0.579	1.008	1.012	0.907
611	0.960	0.938	0.614	0.986	0.913	0.080	0.975	0.935	0.389
604-611	1.054	1.009	0.021	0.966	0.972	0.722	0.987	0.995	0.674

* All values are nonsignificant at P = 0.01

TABLE 2.1-4

Number of total chlorophyll a values in January-December in 1974-1976 outside (X) the 90 percent confidence interval by station for all stations.

Year	1974		1975		1976	
	n	X*	n	X*	n	X*
Station			January-December			
604	19	3	23	1	17	0
605	20	3	23	1	17	1
607	19	4	23	1	17	1
611	20	4	22	3	17	2
604-611	78	14	91	6	68	4

* All outliers are nonsignificant at P = 0.90

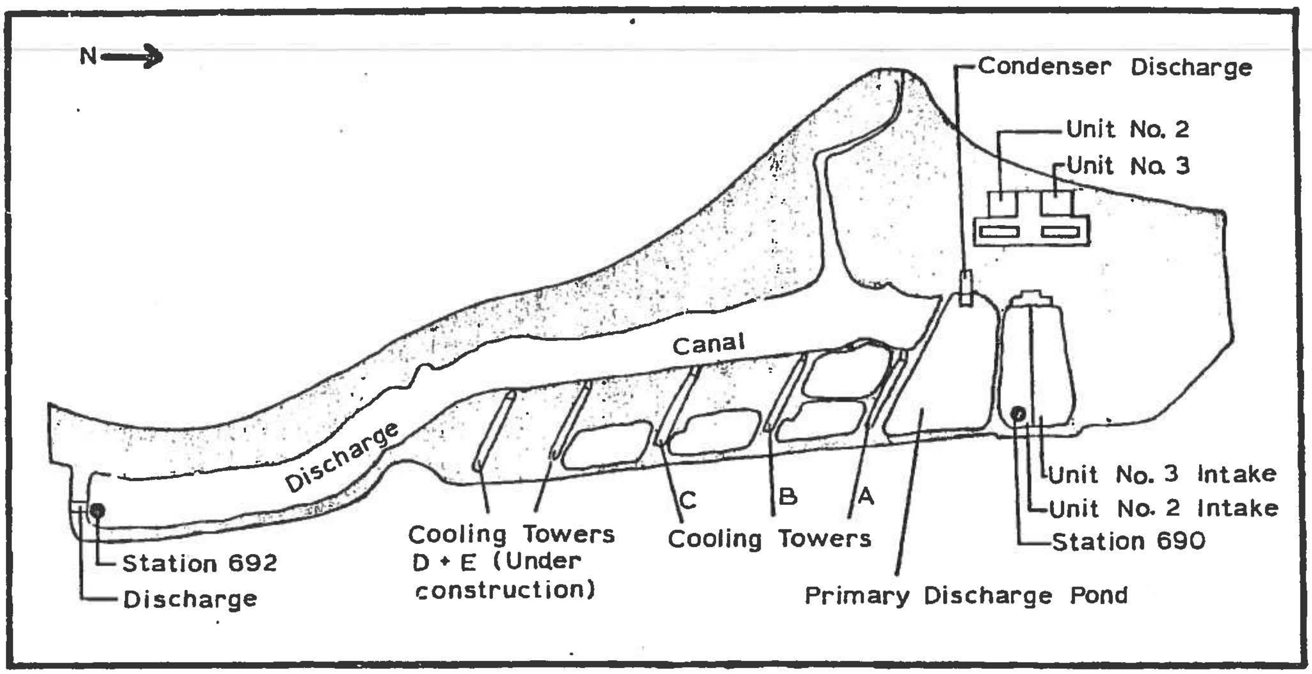

FIGURE 2.1-1

Sampling locations for intake (Station 690) and discharge (Station 692) samples at the Peach Bottom Station.

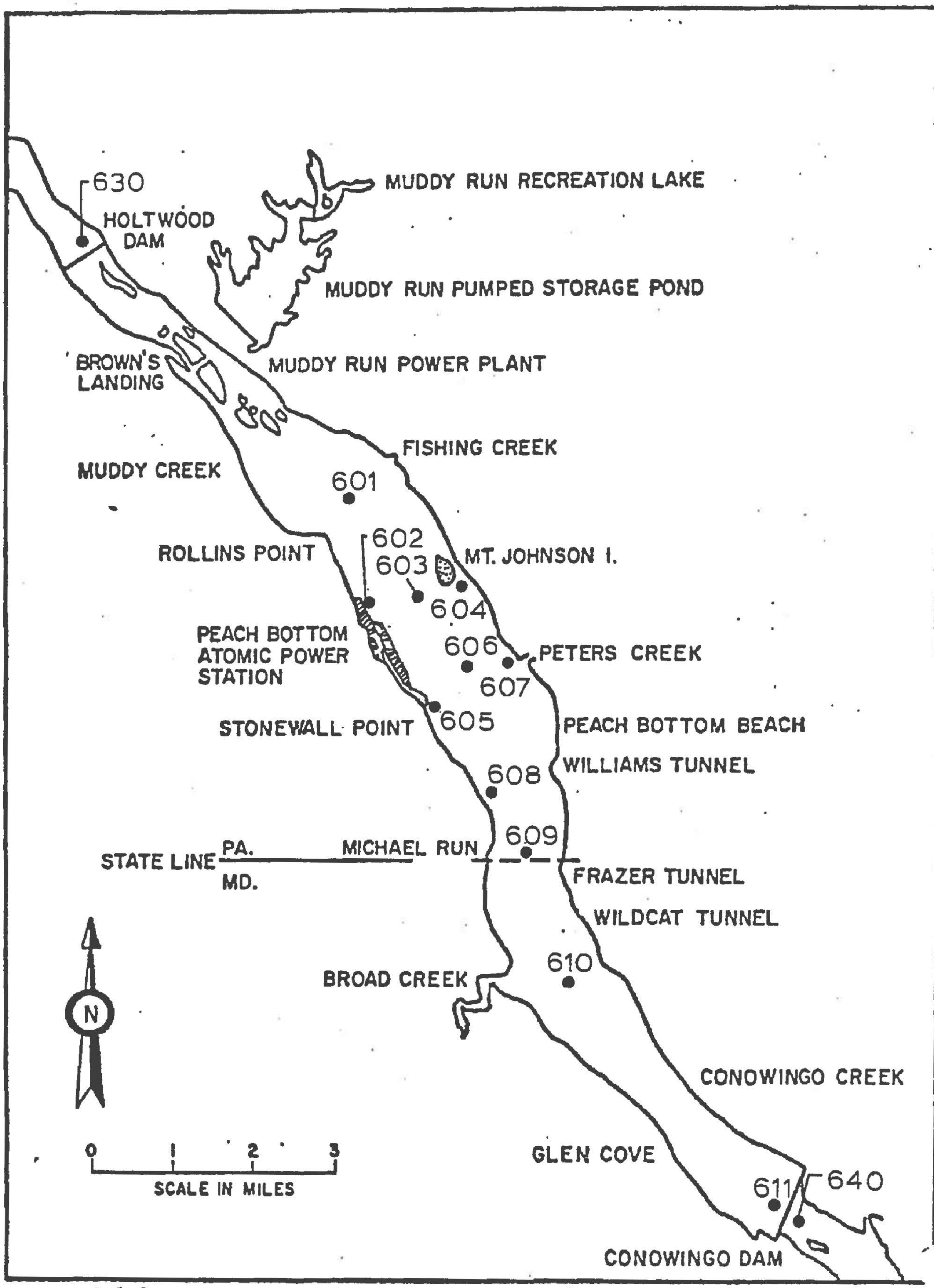

FIGURE 2.1-2

Location of limnological stations in Conowingo Pond.

2.2 ENTRAINMENT OF ZOOPLANKTON

2.2.1 Introduction

Studies on the entrainment of zooplankton in the cooling water system of Peach Bottom began in June 1973. The initial objectives of the study were determination of the species, numbers and life stages affected; estimation of the entrainment mortality and evaluation of the effects of entrainment on the zooplankton population in Conowingo Pond. Collections taken in 1973 established the feasibility of sampling the intake ponds and discharge canal (Figure 2.2-1). The studies were refined in 1974 and the entrainment densities and mortalities were determined. The impact of entrainment on the zooplankton was evaluated from the 1974, 1975 and 1976 data.

Studies by others (see below) indicated that mortality estimates could be biased due to settlement and disintegration of injured zooplankton in the discharge canal. The possibility that avoidance of the sampling gear by zooplankters could be greater in the intakes than the discharge was considered in program design. Gear was selected that would minimize avoidance in the intake.

2.2.2 Methods

Densities of zooplankton in January through May and in October through December were too low (less than 1 animal/liter) to determine mortality. Mortality and species composition of zooplankton was determined only for the period June through September when samples were taken at least every two weeks. Attempts were made to obtain samples at the time of chlorination but the automatic chlorinator had operational difficulties and chlorination was conducted manually on an un-scheduled basis. However, for determination of impact 100% mortality has been assumed for entrainment.

A total of 106 samples of known volume was collected with a VanDorn bottle in 1974 and a Schindler plexiglass plankton trap in 1975 and 1976 at

the intake and discharge structure from June through September. Samples from different depths (surface to bottom) were integrated and filtered through a No. 20 mesh plankton net to represent zooplankton density in the entire water column.

Samples were placed in one pint jars; Carmine Red and Neutral Red dyes were added until dye concentrations were 1% and 5%, respectively. The samples were maintained at ambient temperature in styrofoam containers for one hour or longer to allow stain to concentrate in the live organisms before sorting. Cladocerans and copepods ingested the Carmine Red and concentrated it in their digestive tract while the Neutral Red stained the tissue of live organisms deep red. Dead organisms remained clear or turned a pale pink. Motility also indicated if an organism was alive at the time of collection. Organisms were sorted in the laboratory within two hours after collection. A portion of the sample was placed in a four chambered petri dish and the dead organisms removed by micropipette to a separate vial. This process was repeated until the entire sample was sorted. After sorting, the live and dead organisms were preserved in 40-50% isopropanol in separate vials for later identification and enumeration.

The vial of live organisms was concentrated to a known volume from which successive 1-ml subsamples were placed on a Sedgewick-Rafter counting cell until 200-400 organisms were identified and counted. The total number of live organisms was calculated from the number per volume in the subsample. All dead zooplankters were identified and counted.

In June 1976 a breach was made in the berm separating the primary discharge pond from Conowingo Pond. Most of the heated effluent entered directly into the Pond while the remainder went through the cooling towers and the discharge

canal. The breach did not prevent estimation of zooplankton mortality. The current in the canal was sufficient to prevent the build-up of a large resident population of zooplankton. Thus, the mortality estimate for June 1976 should be comparable to other mortality estimates.

Some investigators have reported that densities in discharges from power plants were lower than at intakes and attributed this to the settling of zooplankton in the discharge. Carpenter, et al. (1974) reported that zooplankton in the discharge of the Millstone Point Nuclear Power Station, Northeastern Long Island Sound exhibited a settling rate of 2-1/2 times that of zooplankton in the receiving water. Lauer, et al. (1974) concluded that organisms settled out in the discharge canal at the Indian Point Nuclear Power Plant on the Hudson River. However, Davies and Jensen (1974) reported no significant densities at the Marshall Steam Station, Lake Norman, North Carolina and Chesterfield Station, James River, Virginia. The discharge samples at the latter two stations were collected within or immediately below the discharge conduit from the condenser. This indicates that disintegration of zooplankton in the condenser may not be significant in estimating mortality. However, settling is considered important in calculating mortality.

In the present study mortalities for all taxa, except nauplii, were calculated from the densities of live and dead animals at the intake and discharge. Densities were adjusted for settling or disintegration of dead animals in the discharge by adding the difference in densities between the intake and the discharge (when this difference was positive) to the densities of the dead animals at the discharge. Thus, the estimate of percentage mortality is maximized. Since nauplii are too small to be accurately sorted into live and dead categories,

mortality was calculated by expressing the difference in density between the intake and discharge as a percentage of the density at the intake. This estimated mortality is due to disintegration and settling.

The percentage dead in the discharge was calculated as the ratio of the density of total dead to the adjusted total density of animals in the discharge. Percentage dead at the intake was subtracted from the percentage dead in the discharge to obtain the percentage mortality due to entrainment.

2.2.3 Results

2.2.3.1 Species Composition

Over 100,000 zooplankters were collected on 37 dates from June through September in 1974, 1975 and 1976. The common taxa and life history stages collected were: Diaphanosoma leuchtenbergianum, Daphnia spp., Bosmina longirostris, nauplii, cyclopoid copepodids and Cyclops vernalis. Others were: Leptodora kindtii, Moina spp., Ceriodaphnia lacustris, Eubosmina coregoni, Ilyocryptus spinifer, Pleuroxus sp., Leydigia cilliata, L. leydigiá, Alonella sp., Chydorus sp., Camptocercus rectirostris, Tropocyclops prasinus, Diaptomus sp., calanoid copepodids and Harpacticoida. No evidence of selective mortality of species was observed. Common taxa in the Pond were most frequently entrained. Total zooplankton density during the study, exclusive of nauplii, ranged from 1.68 (15 July 1976) to 371.34 per liter (26 September 1974) at the intakes and 1.35 (3 July 1974) to 94.85 per liter (20 August 1974) at the discharge (McManus, 1975 and 1977). Total zooplankton density at the intakes was lowest in 1976 (Table 2.2-1).

2.2.3.2 Estimates of Mortality

Estimates of mortality on each date showed a large variation (McManus, 1975, 1976 and IA, 1977b) for the common taxa and all other taxa combined (indicated

herein as "others"). They ranged from -100% for "others" on 16 September 1975 to 100% for Bosmina longirostris on 5 September 1975 and 15 July 1976 for Cyclops vernalis on 18 September 1975. Mean annual estimates ranged from -6% for "others" to 50% for Bosmina longirostris (Table 2.2-2).

Generally, cladocerans suffered greater mortality than copepods (Table 2.2-2). Combined mean mortality of total zooplankton from 1974 to 1976, exclusive of nauplii, was 32%. A paired t-test indicated that zooplankters entrained suffered a significant mortality ($P < 0.01$) in each year. Analysis of variance was run on percent mortality data transformed by the arc sine. No significant differences ($P > 0.05$) occurred in the percent mortalities of total zooplankton between the three years ($F = 2.39$, $df = 2,33$).

2.2.3.3 Impact of Zooplankton Entrainment

Entrainment of zooplankton at Peach Bottom may have some impact on the zooplankton community of Conowingo Pond. However, the impact was not detectable in the Pond by statistical techniques. Any loss in zooplankton population in the Pond would be greatest in the discharge canal and the immediate vicinity of the plume. Enhancement of zooplankton production by the heated effluent, particularly in periods of low (see below), can compensate for losses due to entrainment. Recruitment of zooplankters from upriver sources occurs quickly in the thermal plume.

A zooplankton monitoring program designed to detect changes in the zooplankton population has been conducted since 1967. Zooplankton samples were taken at 11 selected locations throughout the Pond, including the thermal plume (Figure 2.2-2). Data obtained at these stations at about two week intervals were used to make comparisons between the preoperational (1967-1973) and postoperational

(1974-1976) periods. The density of zooplankton at a control station was used as a covariate in analysis of covariance. The aim of the analysis was to isolate the natural variations from those caused by Peach Bottom. The results of the analysis of covariance indicated no significant ($P > 0.01$) changes in the Pond between the preoperational and postoperational periods except in 1975 (Table 2.2-3). The observed densities at most stations in 1975 were not significantly different than in the preoperational period. The exceptions were Stations 610 and 611 in the lower portion of the Pond, an area far removed from the influence of Peach Bottom. The probable reason for significant differences at these two stations may be attributed to predation by a strong year class of gizzard shad. The highest density of gizzard shad larvae was observed near these stations. Gizzard shad larvae are known to feed extensively on zooplankton. Thus, it is concluded that operation of the Peach Bottom has had no detectable effect on the zooplankton population of the Pond. Consequently, the zooplankton losses estimated as a result of entrainment, at most, represent a minimal impact on the Pond.

The total number of organisms entrained was calculated from multiplication of the volume of water which entered Peach Bottom and the average density at the intake (Table 2.2-3). It was assumed that (1) all six circulating water pumps were operating at all times with a capacity of 250,000 gpm each and (2) the efficiency of the Clarke-Bumpus plankton sampler used to collect zooplankton at Station 602 and 612 was 60% compared to the Schindler plexiglass trap (Schindler, 1969). The density of zooplankton at Stations 602 or 612, located closest to the intake structure, was used to estimate the density of zooplankton entrained in May because no data on zooplankton were available from the entrainment study. Stations 602 and 612 are above and directly offshore from the

Peach Bottom intakes, respectively. A Clarke-Bumpus plankton sampler fitted with a No. 20 mesh net was used to collect the sample in a manner similar to that reported by Earle (1974).

The loss of zooplankton differed between the three postoperational years (Table 2.2-4). The greatest loss of zooplankton (1.4×10^{14} organisms) occurred in 1974 and the least was in 1976 (1.1×10^{13} organisms). The relatively high estimated loss in 1974 resulted from a patchy distribution of _B. longirostris_ in September 1974 and of nauplii in August. Both organisms were not abundant either in the samples taken for the NRC monitoring program, particularly at Station 602, or at the discharge. However, inclusion of these data increased the estimates substantially. Consequently, the actual loss was probably much less than that indicated. As mentioned above, these losses were not detectable in the zooplankton community in the Pond.

Even though one may assume that the entrained zooplankton are lost to the food chain, in reality they are available as food for detrital feeders. Consequently, the energy tied up in the live zooplankton is retained in the ecosystem after mortality occurs. This is one of the mechanisms that will compensate, in part, for losses due to Peach Bottom operation.

Increased water temperature enhances the reproductive rate of zooplankton and decreases the time (turnover rate) between succeeding generations of zooplankton (Pratt, 1943; Hall, 1964; McLaren, 1966; Hutchinson, 1967; Heinle, 1969; Carlson, 1974). Thus, the addition of heated water to Conowingo Pond should stimulate production of zooplankton. This effect has been noted at power plants on Lake Michigan and Lake Malaren, Sweden (McNaught, et al., no date; Lanner and Pejler, 1973).

A potential exists for an increase in the zooplankton population in the Pond (Philadelphia Electric Company, 1975). This prediction is made with the knowledge that in the Pond production of zooplankton population generally increases at water temperature greater than 60 F and when river flow is low (< 13,000 cfs). This has been observed both in the preoperational and postoperational periods. At the time (November through May) when low temperature occurs, the river flow is generally high; the zooplankton population is low. In Conowingo Pond high zooplankton production has been observed with a flushing rate of seven days or more when water temperature is suitable for population development. The flow through the Pond must be below 25,000 cfs before the exchange rate will exceed 7 days. Thus, when the release of the heated effluent will raise the ambient water temperature above 60 F and river flow is low, IA predicts an increase in zooplankton production.

TABLE 2.2-1

The density of zooplankton (number per liter) at the intake and discharge of Peach Bottom Station, June-September 1974, 1975 and 1976.

Taxa	1974	1975	1976	Mean
Cladocerans		Intake		
Diaphanosoma leuchtenbergianum	9.18	16.23	2.12	9.18
Daphnia sp.	14.24	0.37	0.74	5.12
Bosmina longirostris	28.31	1.15	1.05	10.17
Copepods				
Nauplii	60.25	16.75	7.78	28.26
Cyclopoid copepodids	14.53	4.86	3.57	7.65
Cyclops vernalis	6.10	0.55	0.66	2.44
Others	8.16	0.83	0.56	3.18
Total Zooplankton*	80.51	23.87	8.66	37.68
Cladocerans		Discharge		
Diaphanosoma leuchtenbergianum	9.10	9.62	1.64	6.79
Daphnia sp.	10.61	0.32	1.16	4.03
Bosmina longirostris	2.64	0.69	0.81	1.38
Copepods				
Nauplii	33.35	16.19	9.00	19.51
Cyclopoid copepodids	10.47	4.94	3.70	6.37
Cyclops vernalis	4.49	0.89	0.75	2.04
Others	4.35	0.99	0.57	1.97
Total Zooplankton*	41.66	17.46	8.63	22.50

* Exclusive of nauplii

TABLE 2.2-2

Estimated percent mortality of zooplankton entrained at the Peach Bottom Station, June-September 1974, 1975 and 1976.

Year	1974 (%)	1975 (%)	1976 (%)	Unweighted Mean (%)
Taxa				
Diaphanosoma leuchtenbergianum	33.87	33.03	19.66	28.85
Daphnia sp.	39.20	23.63	28.86	30.56
Bosmina longirostris	46.18	48.39	39.64	48.07
Cyclopoid copepodids	23.59	17.85	16.82	19.42
Cyclops vernalis	35.68	18.45	12.17	22.10
Others	43.31	5.96	30.55	22.63
Nauplii	47.89	12.34	17.60	25.94
Total Zooplankton*	44.08**[a]	28.66**[b]	23.04**[c]	31.93

* Exclusive of nauplii
** Significant at P = 0.01
a t = 4.38, df = 14
b t = 6.09, df = 10
c t = 4.48, df = 10

TABLE 2.2-3

Comparison of the preoperational (1967-1973) and postoperational (1974-1976) adjusted means of zooplankton densities in Conowingo Pond, January-December.

Station	1974			1975			1976		
	Postop	Preop	P	Postop	Preop	P	Postop	Preop	P
602	.835	.897	.387	.831	.861	.654	.774	.724	.532
603	1.068	.891	.005*	.973	.854	.059	.883	.749	.041
604	1.148	1.013	.049	.980	.979	.991	.994	.925	.401
605	.981	1.000	.786	.966	.962	.959	.906	.869	.618
606	.986	.954	.568	.995	.912	.191	.928	.844	.233
607	1.291	1.158	.110	1.062	1.118	.506	1.063	1.026	.630
608	.949	.977	.684	.907	.929	.736	.939	.842	.168
609	1.061	1.037	.771	.906	.998	.225	1.021	.992	.732
610	1.276	1.246	.682	.929	1.226	.0001*	1.069	1.215	.081
611	1.370	1.267	.186	.971	1.268	.0003*	1.342	1.217	.124
602-611	1.088	1.035	.015	.940	1.001	.0072*	.990	.938	.029

* Significant at $P < 0.01$

TABLE 2.2-4

Estimated zooplankton losses due to entrainment at Peach Bottom Station, May-September 1974-1976.

	Year		
	1974	1975	1976
Amt. of water used per day in the cooling system (liters)	8.176×10^{9}	8.176×10^{9}	8.176×10^{9}
Amt. of water used (liters) from May1-August 15 (107 days)	1.251×10^{12}	8.748×10^{11}	8.748×10^{11}
Total no. of animals entrained	1.385×10^{14}	2.280×10^{13}	1.089×10^{13}

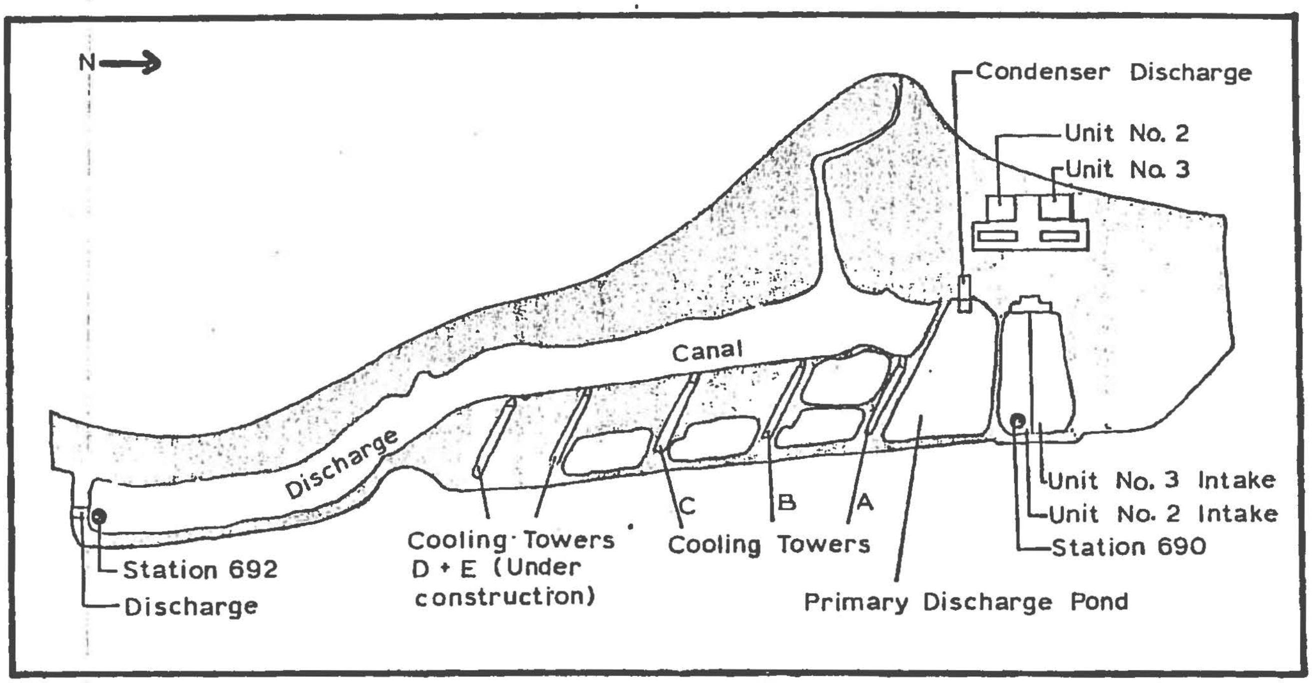

FIGURE 2.2-1

Sampling locations for intake (Station 690) and discharge (Station 692) samples at the Peach Bottom Station.

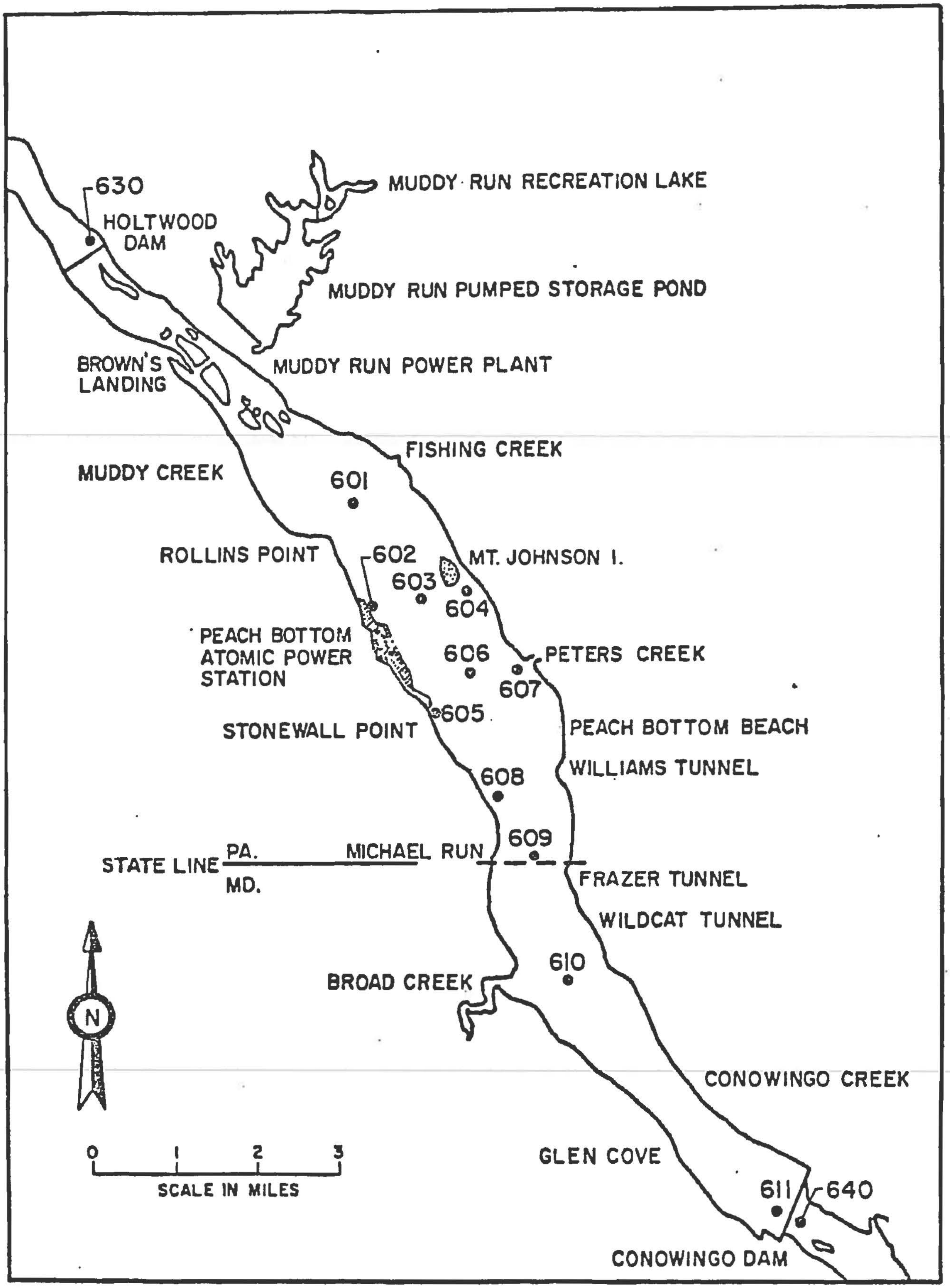

FIGURE 2.2-2

Location of limnological stations in Conowingo Pond monitored since 1967.

2.3 ENTRAINMENT OF FISH LARVAE AND EGGS

2.3.1 Introduction

Studies on the entrainment of fish eggs and larvae in the cooling water system of Peach Bottom began in May 1973. The initial objectives of the study were: (1) determination of the species, numbers and life stages affected; (2) estimation of the entrainment mortality and (3) evaluation of the effects of entrainment on the adult fish populations in the Pond. Collections in 1973 were taken to establish the feasibility of sampling in the intake ponds and discharge canal (Anjard, 1974). The studies were expanded in 1974 and the determination of entrainment mortalities was emphasized. These mortality estimates may be biased due to differential avoidance of the sampling gear by the larvae. The ability of larvae to avoid sampling gear was apparently reduced after passage through the cooling system, thus increasing sampling efficiency in the discharge relative to the intake. Since unbiased estimates of entrainment mortality depend on the uniform efficiency of the sampling gear, further attempts to refine estimates of entrainment mortality were considered futile. Consequently, in 1975 and 1976 estimates of entrainment mortality were obtained without the determination of collection mortality.

Although the densities and entrainment mortalities determined from the 1973 and 1974 data may be biased, they are included herein as Appendices A and B. The impact of entrainment, however, is evaluated from the data collected in 1975 and 1976.

2.3.2 Methods

Weekly samples were taken at three locations (Figure 2.3-1) within the cooling water system from May through July (spawning season). Intake samples were taken by towing a 1.0 m plankton net in the Units No. 2 and 3 intake

ponds. Samples were also taken in the discharge canal, approximately 400 m downstream from cooling tower C with 0.5 m or 1.0 m plankton nets suspended from anchored buoys. All nets had a mesh size of 0.4 x 0.7 mm. In 1975, the Unit No. 3 intake was sampled only when Unit No. 2 was not operating. In 1976, both intakes were sampled whenever possible (see below). Two surface and two bottom collections were taken at each location in the daytime and at night.

A General Oceanics Model 2030 flow meter mounted in the mouth of each net was used to determine the volume of water filtered in each sample. In 3% of the collections the meter became clogged with debris and the exact volume could not be determined. In these cases, the sample was assigned the average volume per collection for the entire season. Densities were expressed as the number of larvae per 1000 m^3.

The nets were set or towed for 10 minutes, retrieved and the samples processed. Intake samples were immediately preserved in 10% formalin and the larvae sorted at a later date. Fish eggs or larvae collected in the intake ponds were considered to be entrained. Discharge samples were emptied into individual, aerated styrofoam containers and live and dead larvae were separated on site. Specimens that showed movement when placed in 10% formalin were considered alive. The time from collection to sorting of live and dead larvae was usually less than one-half hour but never more than one hour. Specimens were initially preserved in 10% formalin and later transferred to 40% isopropanol, counted and measured. Eggs and larvae were identified to species where possible. Larvae of bluegill and pumpkinseed could not be separated, thus data for these larvae were combined and categorized as sunfishes. Because of the low numbers of eggs and larvae in individual

samples, the data from all collections on a given date and location were pooled for analysis.

Temporary shutdowns or construction activities at Peach Bottom occasionally precluded sampling. Intake samples were not taken for a given unit if the circulating water pumps for that unit were not operating. Discharge samples were not taken if fewer than three pumps (of a total of six) were operating. In addition, discharge samples were not taken in June 1976 when most of the cooling water bypassing the discharge canal and was discharged directly into Conowingo Pond through a break in the berm of the primary discharge pond.

The distribution and abundance of fish larvae in the Pond were determined from data collected in 1969 through 1976 ichthyoplankton monitoring programs. These data are used herein to identify spawning patterns and locations in the Pond, and to evaluate the impact of entrainment.

Since the results of the 1973 and 1974 programs indicated that attempts to determine collection mortality would be futile, only estimates of the minimum and maximum entrainment mortality were calculated for the 1975 and 1976 data. The minimum estimate of mortality was defined as the percentage loss due to settling and disintegration of larvae between the intake and discharge. The maximum estimate of mortality combined settling and disintegration losses together with the mortalities observed in the discharge collections.

$$\text{Minimum mortality} = \frac{\text{Density at the intake} - \text{Density at the discharge}}{\text{Density at the intake}}$$

$$\text{Maximum mortality} = \frac{\text{Density of dead larvae at discharge} + \text{Density at the intake} - \text{Density at the discharge}}{\text{Density at the intake}}$$

2.3.3 Results

Few eggs are taken in ichthyoplankton tows because most fishes in the Pond are nest builders or demersal spawners with adhesive eggs. A total of seven eggs was collected in entrainment samples over the two year period. Thus, entrainment of fish eggs is not considered a potential problem at Peach Bottom.

Larvae of 20 species were entrained in the cooling system in 1975 and 1976. The most common were larvae of the gizzard shad, carp, quillback, channel catfish and tessellated darter (Table 2.3-1). The gizzard shad, carp and quillback (rough fishes) made up over 80% of the entrained larvae while larvae of sunfishes (bluegill and pumpkinseed), smallmouth bass, white crappie and walleye (pan and game fishes) comprised 2%. The mean density of larvae in the 1975 and 1976 spawning seasons was 131.6 per 10^3m^3 of which 57.97 per 10^3m^3 (44%) were gizzard shad.

Differences in the entrainment at Units No. 2 and 3 were evaluated using the densities of fish collected at the intakes on dates when both units were sampled in 1976 (Table 2.3-2). Unit No. 2 was shutdown for much of the sampling season, and data from four sampling dates were available for comparisons. The densities of larvae at each unit were similar, and Spearman rank correlations indicated that the species rankings at the two intakes were the same ($N = 11$, $r_s = .793$, $P \leq .01$). Since the samples from the two intakes apparently represented samples drawn from the same population, the data from both intakes were combined and mean intake densities calculated.

Entrainment varied over the three month sampling season. The highest densities of the commonly entrained fish larvae occurred between the last week in May and the first week in July (Table 2.3-3). From May through early

June larvae of the carp and quillback were abundant, while from mid-June until mid-July the gizzard shad and channel catfish predominated. The larvae of sunfishes were usually entrained in June and July; the shield darter and tessellated darter in June.

Estimates of entrainment mortality were determined for seven species (Table 2.3-4). Since cooling tower construction (break in the berm) prevented sampling at the discharge in June of 1976, only the 1975 results were used for mortality estimates. In general, smaller, more fragile larvae experienced higher mortalities than did larger, more robust larvae. Gizzard shad larvae (mean length 4 mm) experienced the greatest mortality (98-100%) and channel catfish (mean length 17 mm) the least (75-79%). The entrainment mortality for all species combined was between 85 and 93%. Since these estimates did not include consideration of delayed mortalities resulting from thermal or mechanical shock, 100% mortality was assumed for all species in assessment of impact. This is in accordance with studies cited by Marcy (1975) where, in all but one case, the mortality of entrained larvae was placed between 90 and 100%.

Mechanical damage rather than heat shock appeared to be the common cause of entrainment mortality at Peach Bottom. The reductions in numbers of larvae between the intake and discharge accounted for about 90% of the estimated mortality. These reductions were believed to have resulted from the mechanical destruction (disintegration) of larvae in the pumps, condensers or cooling towers, since sufficient turbulence is present throughout the cooling system to permit suspension of dead (although intact) larvae.

2.3.4 Projected Losses

Estimates of the numbers of fish larvae lost each year through entrainment (assuming 100% mortality) were calculated from the mean intake densities over

the sampling season (Table 2.3-5) and a maximum water intake of 3350 cfs (1,500,000 gal/min). Entrainment losses were estimated for a 100 day period, which approximates the period fish larvae would be vulnerable to entrainment. These estimates were used to calculate the average number of adults lost per year (Table 2.3-5).

The most conservative (although unrealistic) estimates of the impact of entrainment on the populations of adult fishes would assume that the losses of adults were directly equal to the losses of larvae. A more reasonable estimate, however, would take into account that only a fraction of the numbers of larvae entrained would have survived to adulthood under natural conditions. This larval to adult survival rate can vary by several orders of magnitude depending on the fecundity and spawning habits of the species of concern as well as the geographic locality and year. Data on survival rates are not available for Conowingo Pond but are available from other studies for some species. Survival rates have been reported as low as 0.005% for the gizzard shad from egg to age II+ (Bodola, 1966) or as high as 2% for carp sucker from larvae to age III+ (Jester, 1972). Some environmental impact studies have based survival rates on fecundity estimates (Houston Lighting and Power Co., 1974) while others have assigned a "realistic" survival rate of 0.1% (Potomac Electric Power Co., 1973). Herein, a survival rate of 0.01% was assumed for larvae of species with high relative fecundities (gizzard shad, carp and quillback), while 0.1% survival was assumed for the larvae of the remaining species with low relative fecundities (Table 2.3-5). Given the above assumptions, the estimated annual losses of adult pan and sport fishes would be as follows: 3,450 channel catfish, 1,130 sunfish (mostly bluegill), 490 walleye and 380 white crappie (Table 2.3-5).

These losses of adults, however, should be placed in some perspective by comparison with other known sources of mortality. For example, the estimated losses of adults resulting from the entrainment of larvae might be compared to losses which result from angler exploitation. In the present study angler exploitation data were only available for the white crappie. Generally, the white crappie supports the fishery in Conowingo Pond (Whitney, 1961) and is taken primarily in the winter months. The angler exploitation rate for white crappie during the winter of 1973 was estimated at 9% (Euston, et al., 1974). The bluegill was also caught in the winter fishery but observations indicate that its exploitation was lower than that of the white crappie. Although the exploitation rate may vary greatly between years due to several factors including fluctuations in year class strength, 9% is the best available estimate of present angler exploitation. Data from Euston (1976) indicated that anglers took approximately 28,000 bluegill and 25,000 white crappie from Conowingo Pond in the winter of 1975. The loss of 380 adult white crappie and 1,130 sunfishes (mostly bluegill) due to entrainment of larvae would represent an additional exploitation of less than 1%. The total exploitation rate (angler plus entrainment) would then approach 10%. Although exploitation rates are not available for the channel catfish and game fishes, McFadden (1975) indicated that exploitation rates of 25% and higher are common for freshwater fishes such as the channel catfish, bluegill, smallmouth bass and walleye. The fish populations in Conowingo Pond should therefore be able to compensate for the increased exploitation represented by Peach Bottom without significant reductions.

In addition to the losses of pan and game fishes, the yearly losses of rough fishes would approach 4,770 gizzard shad, 2,010 carp and 2,240 quillback

(Table 2.3-5). These species are present in large numbers throughout Conowingo Pond and, in their larval and juvenile stages, are used to some degree as forage by predatory fishes. However, the large adult populations and high fecundity of these species (together with the dramatic increases in the gizzard shad populations in recent years) indicate that the expected losses should be well within the compensatory reserve of the populations.

2.3.5 Impact of Entrainment

To detect the possible impact of entrainment on the Pond, comparisons were made between the preoperational (1969-1973) and postoperational (1974-1976) densities of fish larvae. The mean preoperational densities of larvae were calculated and compared to the postoperational densities. Consistent decreases from the preoperational mean were noted for the white crappie and sunfishes (bluegill and pumpkinseed) indicating decreased larval densities in the postoperational period (Table 2.3-6). Since the introduction of the gizzard shad and Tropical Storm Agnes occurred late in the preoperational period (1972) and may have influenced these reductions, the period prior to 1972 was compared to 1973 and the postoperational years (Table 2.3-6). The initial reductions in the populations of white crappie and other sunfishes occurred in 1973; the year following Tropical Storm Agnes but prior to initial start-up of Peach Bottom. No further declines were noted in subsequent years, despite the operation of Peach Bottom.

The location of cooling water intakes in relation to the known spawning areas is an important consideration in determining the impact of entrainment. Spawning locations (Figures 2.3-2 to 2.3-8) were determined from the catches of newly hatched larvae at stations throughout the Pond. The presence of

these larvae in a given area was considered evidence of spawning. The catch per tow of newly hatched larvae was then expressed as a density index:

$$\frac{\text{Catch per effort at a station or area}}{\text{Average catch per effort at all other stations or areas}}$$

An index of less than one indicated areas of less than average importance while an index greater than one indicated areas of greater than average importance (Robbins and Mathur, 1976b).

All the "representative, important species" spawn to some degree in the vicinity of the intake (Figures 2.3-2 to 2.3-8). However, each uses other areas in the Pond as principal spawning sites. The creeks and coves in the southern section of the Pond are used extensively by the gizzard shad, sunfishes (bluegill and pumpkinseed) and white crappie and walleye while the smallmouth bass and spotfin shiner concentrate in the northern sections or along the eastern shore. The channel catfish spawns primarily along the eastern shore, north of Peach Bottom and south of the discharge along the western shore. In each case larvae in the primary spawning areas are not subject to entrainment. In at least one species (smallmouth bass) construction of Peach Bottom may have increased the area available for spawning. The rip-rap used to surface the sides of the berm provided a spawning habitat for this species. This appears to be one of the few areas in the central or southern sections of the Pond where the smallmouth bass spawns (Figure 2.3-5) although the densities of larvae are low and few are entrained.

TABLE 2.3-1

Mean densities of larval fishes ($\leq$ 25 mm) per $10^3 m^3$ at the intakes of Peach Bottom Station, May-July, 1975-1976.

Year	1975	1976	Mean
Volume Sampled (10^3 m^3)	14.9	16.7	15.8
Species			
Gizzard shad	34.78	78.57	57.97
Unidentified Minnows	3.30	0.60	1.87
Carp	6.93	35.31	21.95
Golden shiner	0.00	0.06	0.03
Comely shiner	0.07	0.06	0.06
Spottail shiner	0.07	0.06	0.06
Spotfin shiner	0.07	0.12	0.10
Creek chub	0.00	0.06	0.03
Unidentified Suckers	0.13	0.00	0.06
Quillback	27.58	25.73	26.61
White sucker	0.27	0.66	0.48
Yellow bullhead	0.00	0.12	0.06
Channel catfish	4.71	4.13	4.40
Rock bass	0.13	0.00	0.06
Redbreast sunfish	0.07	0.00	0.03
Smallmouth bass	0.40	0.00	0.19
White crappie	0.34	0.60	0.48
Sunfishes	1.48	1.44	1.46
Tessellated darter	5.79	8.68	7.32
Log perch	0.07	0.00	0.03
Shield darter	5.25	1.62	3.33
Walleye	0.74	0.30	0.57
Unidentifiable	0.54	8.14	4.56
Total	92.70	166.24	131.64

TABLE 2.3-2

Densities of larval fishes ($\leq$ 25 mm) per 10^3m^3 at the Peach Bottom Station Units No. 2 and 3 intakes on 28 June, 6, 19 and 26 July 1976.

Volume Sampled (10^3m^3)	Unit No. 2 6.0	Unit No. 3 6.0
Species		
Gizzard shad	2.83	3.19
Unidentified Minnows	0.50	0.50
Carp	2.49	1.34
Comely shiner	0.17	0.34
Spottail shiner	0.00	0.17
Spotfin shiner	0.17	0.17
Quillback	0.00	0.50
Yellow bullhead	0.00	0.34
Channel catfish	9.48	6.54
White crappie	0.00	0.17
Sunfishes	0.83	0.67
Shield darter	0.33	0.34
Total	16.80	13.93

TABLE 2.3-3

Mean densities of common larval fishes (≤ 25 mm) per $10^3 m^3$ at the intake of the Peach Bottom Station from May through July, 1975-1976.

Month	May				June					July			
Week Sampled	1st	2nd	3rd	4th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th
Species													
Gizzard shad													
1975	0.00	0.00	-	7.11	62.65	0.00	1.60	120.36	41.41	153.71	14.26	7.51	0.00
1976	17.88	-	21.10	13.07	79.53	35.67	503.42	298.98	8.84	0.68	4.85	1.30	1.60
Carp													
1975	0.00	0.00	-	32.00	14.86	7.94	1.60	4.09	14.05	0.00	5.87	3.00	0.00
1976	3.58	-	0.00	458.40	4.54	0.78	20.55	4.87	2.12	5.78	5.34	0.00	0.00
Quillback													
1975	0.00	0.00	-	16.90	22.68	237.63	16.02	4.09	4.44	1.56	0.00	0.00	0.00
1976	11.44	-	4.92	219.61	82.56	26.37	7.90	0.70	0.35	0.00	0.00	0.00	0.00
Channel catfish													
1975	0.00	0.00	-	0.00	0.00	0.00	0.00	1.64	27.36	20.28	2.51	0.75	0.75
1976	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	13.43	12.59	15.24	4.53	1.92
Sunfishes													
1975	0.00	0.00	-	0.00	1.56	0.72	0.00	0.82	6.65	0.78	5.87	0.00	0.00
1976	0.00	-	0.00	0.87	0.00	0.00	1.58	8.34	1.06	0.68	2.77	0.00	1.28
Tessellated darter													
1975	0.00	7.35	-	28.50	10.95	8.67	8.01	0.82	5.91	0.00	0.84	0.00	0.00
1976	16.45	-	0.00	5.23	8.33	4.65	15.02	55.62	0.00	0.00	0.00	0.00	0.00
Shield darter													
1975	0.00	0.94	-	2.67	7.82	13.72	29.64	3.27	2.22	0.00	0.84	0.00	0.00
1976	0.72	-	2.11	0.00	9.85	1.55	0.79	3.48	0.71	0.34	0.69	0.32	0.00
Total Density (All Larvae)													
1975	3.98	15.99	-	96.00	130.59	290.33	64.08	139.99	104.26	176.33	39.58	11.26	0.75
1976	54.37	-	28.13	792.17	207.54	71.35	557.16	379.65	29.69	21.09	31.16	6.47	5.12

TABLE 2.3-4

Densities (number per 1000 m^3) of fish larvae (≤ 25 mm) in the intake and discharge canals, maximum and minimum estimates of entrainment mortality together with station operating conditions at Peach Bottom Station, from May-July 1975.

Week of:	4 May	11 May	25 May*	1 Jun*	8 Jun	15 Jun
Air Temp (F)	54.0-68.0	61.5-72.0	72.5-82.0	66.0-72.0	59.0-76.5	69.0-79.0
Water Temp (F)						
Intake	56.0-58.0	60.0-62.0	72.5-74.0	74.0-75.0	65.0-66.0	72.0
Discharge	73.0-73.5	75.5-76.0	81.5-84.0	76.0-78.0	73.0-75.0	80.0-81.0
ΔT (F)	16.25	14.8	9.5	2.5	8.5	8.5
Percent Power	188	199	98-99	52	91-115	108-119
No. Circulating Pumps	6	6	4	4	6	6
No. Cooling Towers	2	3	2	3	2-3	3
Species						
D. cepedianum						
Density						
Intake	-	-	7.11	62.65	0.00	1.60
Discharge	-	-	0.00	0.00	0.73	0.00
% Mortality						
Maximum	-	-	100.00	100.00	-	100.00
Minimum	-	-	100.00	100.00	-	100.00
C. carpio						
Density						
Intake	0.00	0.00	32.0	14.86	7.94	1.60
Discharge	1.03	1.66	6.51	4.39	2.93	0.00
% Mortality						
Maximum			93.22	100.00	100.00	100.00
Minimum			79.66	70.46	63.10	100.00
C. cyprinus						
Density						
Intake	0.00	0.00	16.90	22.68	237.63	16.02
Discharge	5.15	0.83	3.26	4.39	52.06	1.17
% Mortality						
Maximum			100.00	80.64	87.66	92.70
Minimum			80.71	80.64	78.09	92.70
I. punctatus						
Density						
Intake	-	-	0.00	0.00	0.00	-
Discharge	-	-	1.09	1.09	5.86	-
% Mortality						
Maximum	-	-				-
Minimum	-	-				
Lepomis spp.						
Density						
Intake	-	-	0.00	1.56	0.72	-
Discharge	-	-	1.09	0.00	0.00	-
% Mortality						
Maximum	-	-		100.00	100.00	-
Minimum	-	-		100.00	100.00	-
E. olmstedi						
Density						
Intake	0.00	7.35	28.5	10.95	8.67	8.01
Discharge	3.09	1.66	0.00	2.19	0.00	0.00
% Mortality						
Maximum		88.98	100.00	80.00	100.00	100.00
Minimum		77.41	100.00	80.00	100.00	100.00
P. peltata						
Density						
Intake	0.00	0.94	2.67	7.82	13.72	29.64
Discharge	1.03	0.00	0.00	2.18	5.13	0.58
% Mortality						
Maximum		100.00	100.00	86.06	83.97	98.04
Minimum		100.00	100.00	72.12	62.61	98.02
Others						
Density						
Intake	3.98	7.52	8.89	10.16	21.65	7.21
Discharge	3.09	4.99	1.09	0.00	7.31	0.00
% Mortality						
Maximum	74.12	88.96	87.74	100.00	79.72	100.00
Minimum	22.36	33.64	87.74	100.00	66.24	100.00
Total						
Density						
Intake	3.98	15.99	96.00	130.59	290.33	64.08
Discharge	19.58	9.97	13.04	14.24	74.02	1.75
% Mortality						
Maximum	-	89.62	95.47	93.29	85.61	97.27
Minimum		37.65	86.42	89.10	74.50	97.27

continued

TABLE 2.3-4

Continued.

Week of:	22 Jun	29 Jun	6 Jul	13 Jul	20 Jul	27 Jul	
Air Temp (F)	74.0-89.0	72.0-81.0	70.0-82.0	75.0-80.0	76.0-88.0	72.0-85.0	
Water Temp (F)							
Intake	79.0-79.5	75.0	79.5-80.0	77.0-78.0	80.5	81.0-82.0	
Discharge	81.5-83.0	84.0-85.0	85.0-86.0	83.0-84.0	87.0	86.0-89.0	
Δ T (F)	3.0	9.5	5.8	6.0	6.5	6.0	
Percent Power	48	142	100	100	100	106	
No. Circulating Pumps	4	6	6	6	6	6	
No. Cooling Towers	2-3	3	3	3	2	2	Mean
Species							
D. cepedianum							
Density							
Intake	120.36	41.41	153.71	14.26	7.51	-	
Discharge	0.00	3.73	0.81	1.56	2.18	-	
% Mortality							
Maximum	100.00	100.00	100.00	100.00	100.00	-	100.00
Minimum	100.00	90.99	99.47	89.06	70.97	-	97.61
C. carpio							
Density							
Intake	4.09	14.05	-	5.87	3.00	-	
Discharge	0.00	3.73	-	4.68	0.72	-	
% Mortality							
Maximum	100.00	89.40	-	73.42	100.00	-	93.07
Minimum	100.00	73.45	-	20.27	76.00	-	71.00
C. cyprinus							
Density							
Intake	4.09	4.44	1.56	-	-	-	
Discharge	1.46	0.74	0.81	-	-	-	
% Mortality							
Maximum	64.30	100.00	100.00	-	-	-	86.95
Minimum	64.30	83.33	48.08	-	-	-	77.63
I. punctatus							
Density							
Intake	1.64	27.36	20.28	2.51	0.75	0.75	
Discharge	0.00	2.98	0.81	0.78	0.72	0.00	
% Mortality							
Maximum	100.00	91.81	100.00	68.92	100.00	100.00	79.41
Minimum	100.00	89.11	96.01	68.92	4.00	100.00	74.95
Lepomis spp.							
Density							
Intake	0.82	6.65	0.78	5.87	-	0.00	
Discharge	0.00	2.24	0.00	1.56	-	0.67	
% Mortality							
Maximum	100.00	100.00	100.00	100.00	-		100.00
Minimum	100.00	66.32	100.00	73.42	-		65.96
E. olmstedi							
Density							
Intake	0.82	5.91	-	0.84	-	-	
Discharge	0.00	0.74	-	0.00	-	-	
% Mortality							
Maximum	100.00	100.00	-	100.00	-	-	93.96
Minimum	100.00	87.48	-	100.00	-	-	90.50
P. peltata							
Density							
Intake	3.27	2.22	-	0.84	-	-	
Discharge	0.00	0.74	-	0.00	-	-	
% Mortality							
Maximum	100.00	100.00	-	100.00	-	-	93.33
Minimum	100.00	66.67	-	100.00	-	-	84.19

continued

TABLE 2.3-4

Continued.

Week of:	22 Jun	29 Jun	6 Jul	13 Jul	20 Jul	27 Jul	
Air Temp (F)	74.0-89.0	72.0-81.0	70.0-82.0	75.0-80.0	76.0-88.0	72.0-85.0	
Water Temp (F)							
Intake	79.0-79.5	75.0	79.5-80.0	77.0-78.0	80.5	81.0-82.0	
Discharge	81.5-83.0	84.0-85.0	85.0-86.0	83.0-84.0	87.0	86.0-89.0	
ΔT (F)	3.0	9.5	5.8	6.0	6.5	6.0	
Percent Power	48	142	100	100	100	106	
No. Circulating Pumps	4	6	6	6	6	6	
No. Cooling Towers	2-3	3	3	3	2	2	Mean
Species							
Others							
Density							
Intake	4.90	2.22	-	8.39	-	0.00	
Discharge	0.00	0.00	-	0.78	-	0.67	
% Mortality							
Maximum	100.00	100.00	-	90.70	-		91.32
Minimum	100.00	100.00	-	70.70	-		65.60
Total							
Density							
Intake	139.99	104.26	176.33	38.58	11.26	0.75	
Discharge	1.46	14.90	2.43	9.36	3.62	1.34	
% Mortality							
Maximum	98.96	96.42	100.00	93.93	100.00	-	93.13
Minimum	98.96	85.71	98.62	75.74	67.85		84.68

$$\text{Minimum Mortality} = \frac{\text{Density at the intake} - \text{Density at the discharge}}{\text{Density at the intake}}$$

$$\text{Maximum Mortality} = \frac{\text{Density of dead larvae at discharge} + \text{Density at the intake} - \text{Density at the discharge}}{\text{Density at the intake}}$$

TABLE 2.3-5

Estimated number of larval fishes (≤ 25 mm) entrained and projected losses of adults at Peach Bottom Station in 1975 and 1976.

	1975		1976		1975 AND 1976		
	No. Entrained* X 10^6	2SE X 10^6	No. Entrained* X 10^6	2SE X 10^6	No. Entrained X 10^6	Adults lost	Larvae to adult survival rate
Species							
Gizzard shad	27.91	30.23	67.40	74.17	47.66	4,770	0.01
Carp	5.70	4.49	34.57	62.08	20.14	2,010	0.01
Spotfin shiner	0.05	0.03	0.10	0.07	0.08	80	0.1
Quillback	20.72	31.87	24.16	30.44	22.44	2,240	0.01
Channel catfish	3.64	15.10	3.26	2.88	3.45	3,450	0.1
Smallmouth bass	0.30	0.59	0.00	0.00	0.15	150	0.1
White crappie	0.27	0.43	0.49	0.37	0.38	380	0.1
Sunfish spp.	1.12	1.11	1.13	1.11	1.13	1,130	0.1
Walleye	0.72	1.01	0.25	0.25	0.49	490	0.1

No. adults lost = (No. larvae lost) X (larval to adult survival rate)

No. Entrained per Year = (Average* no./m^3) X (93.8 m^3/s) X (8.64 x 10^4s/day) X (100 days/year)

* Computed using weekly mean densities

TABLE 2.3-6

Comparison of the preoperational (1969-1973) and postoperational (1974-1976) densities (per $10^3 m^3$) of some larval fishes ($\leq$ 25 mm) at transect stations in Conowingo Pond.

Year	1969-1971	1969-1973[1]	1973	1974	1975	1976	1974-76 Mean
Species							
Gizzard shad[2]	-	-	1.16	0.23	156.10	210.03	122.12
Spotfin shiner	0.35	0.28	0.08	1.02	0.43	0.48	0.64
Channel catfish	11.70	10.52	6.98	5.65	18.22	10.32	11.40
Smallmouth bass	0.19	0.15	0.02	0.04	*	0.20	0.08
White crappie	4.50	3.49	0.45	0.87	0.18	0.47	0.51
Sunfishes	14.13	11.10	1.98	1.52	2.04	2.23	1.93
Walleye	0.10	0.11	0.11	0.04	0.29	0.04	0.12

1 - 1972 not included because of incomplete sampling
2 - Gizzard shad were not present prior to 1972
* - < 0.01

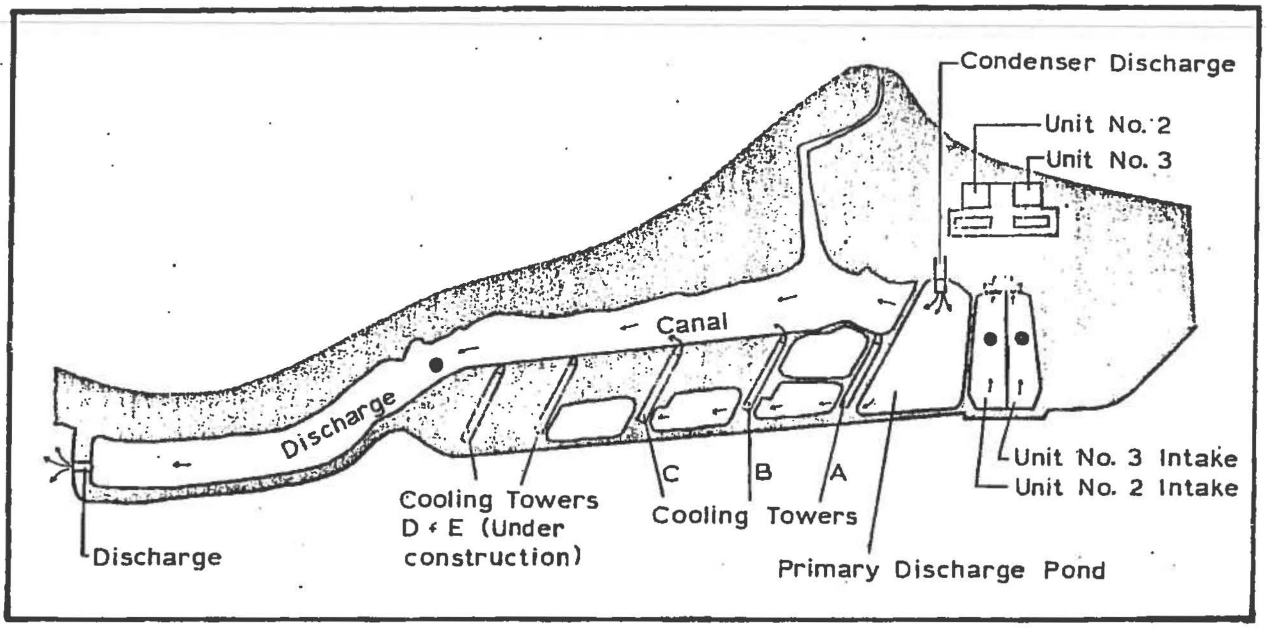

FIGURE 2.3-1

Diagram of the cooling water system of Peach Bottom Atomic Power Station, Units No. 2 and 3, on Conowingo Pond. Ichthyoplankton sampling stations are indicated as dots.

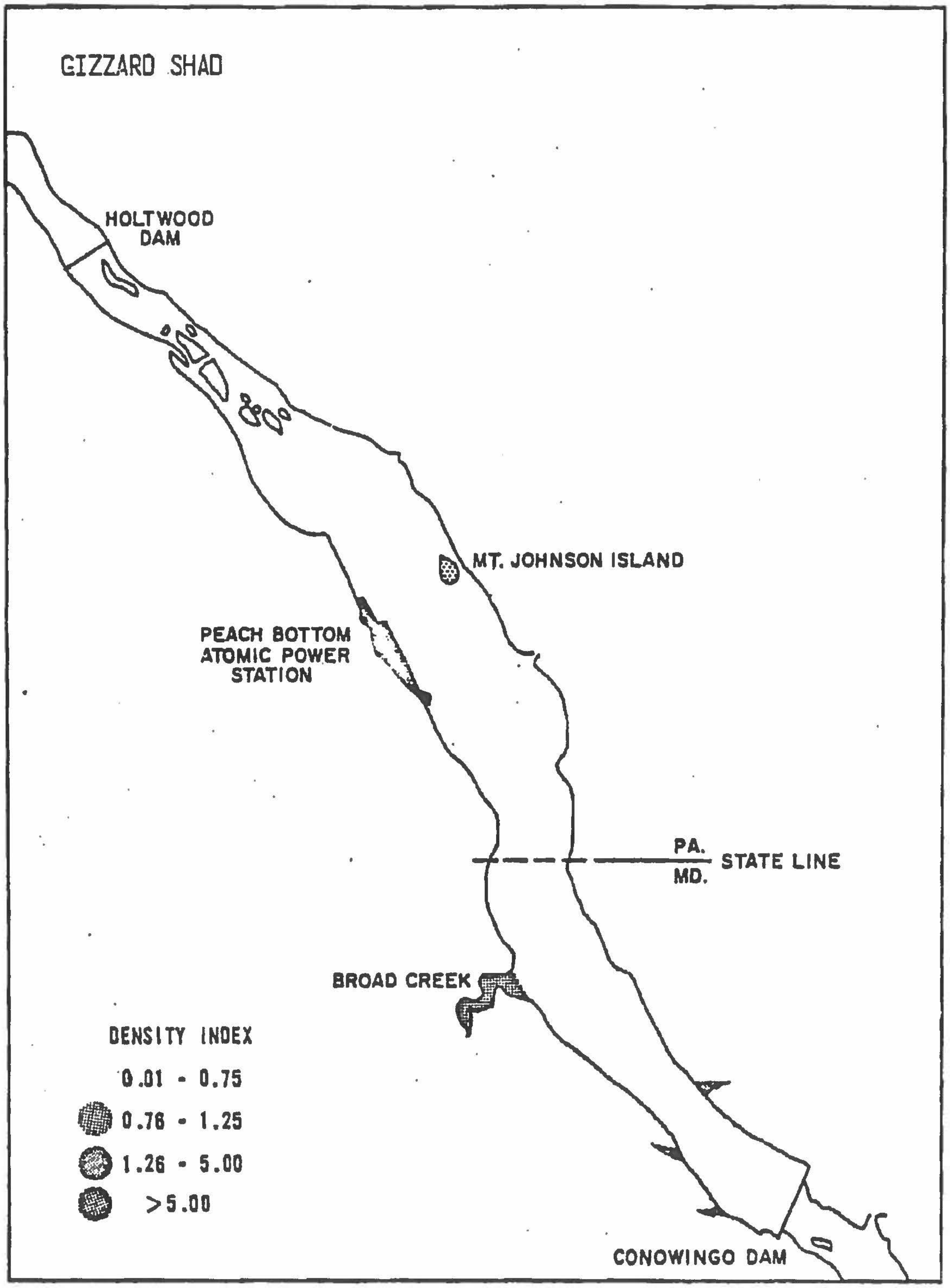

Figure 2.3-2

Location of spawning areas of the gizzard shad, Conowingo Pond.

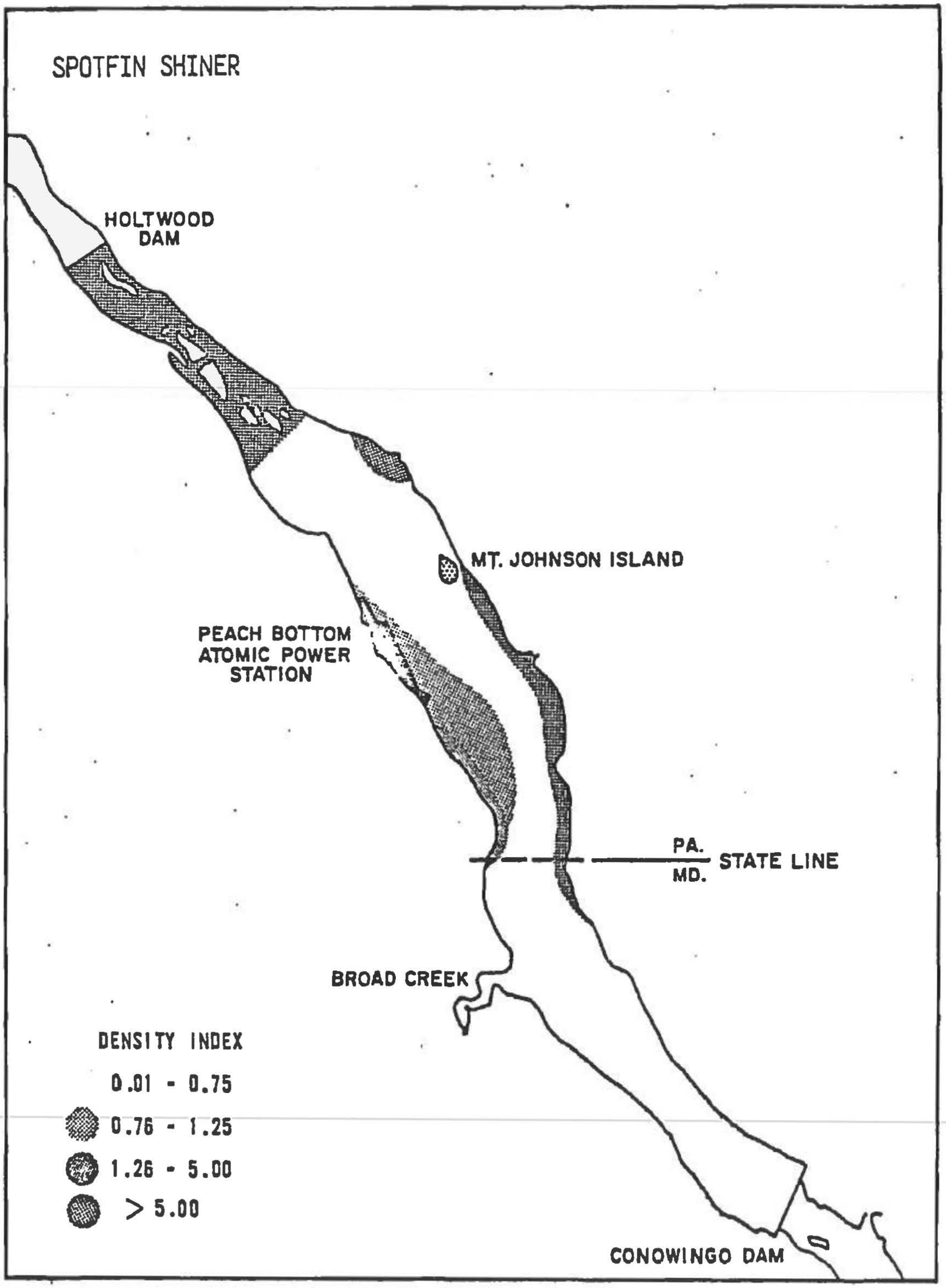

Figure 2.3-3

Location of spawning areas of the spotfin shiner, Conowingo Pond.

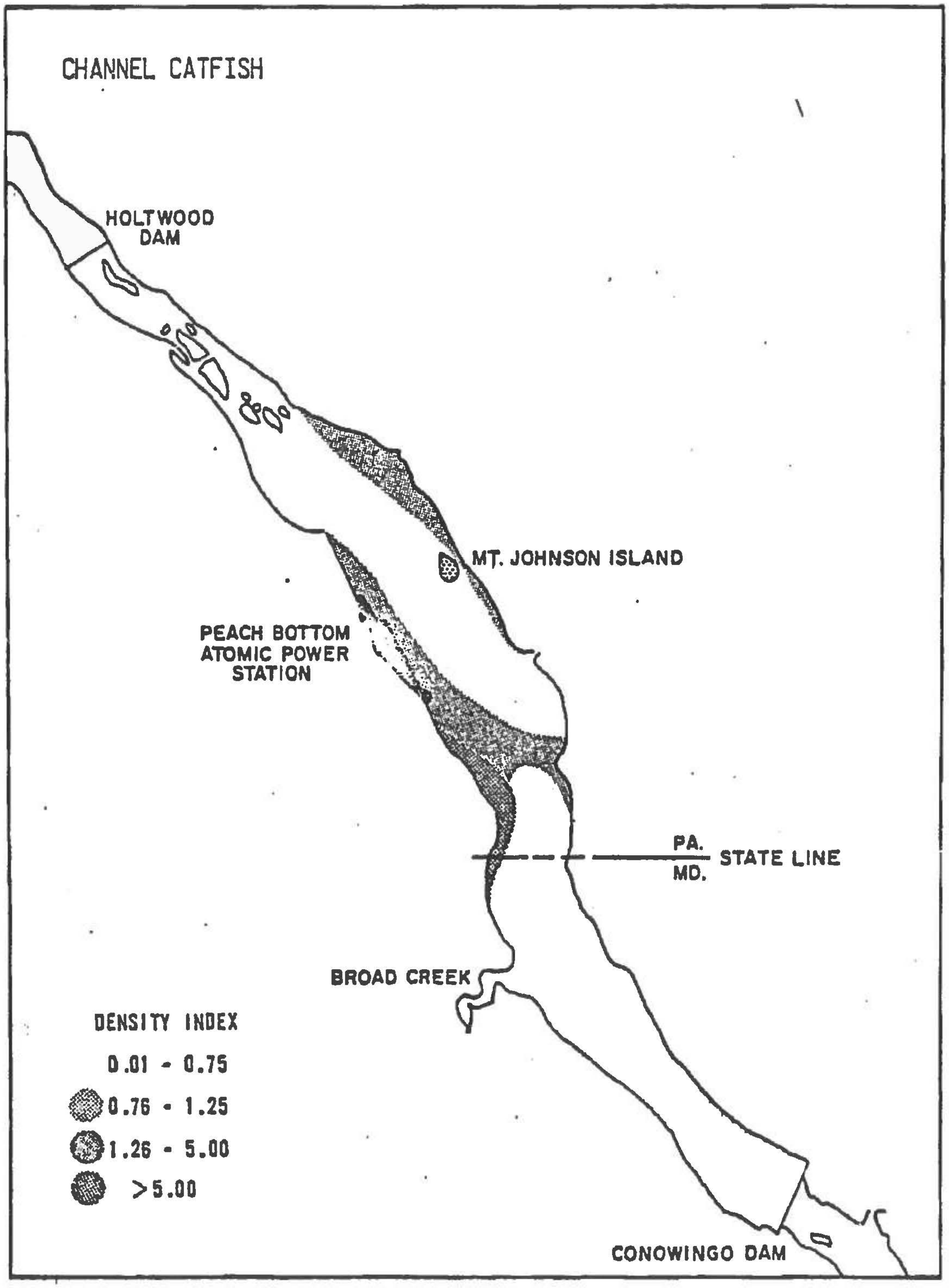

Figure 2.3-4

Location of spawning areas of the channel catfish, Conowingo Pond.

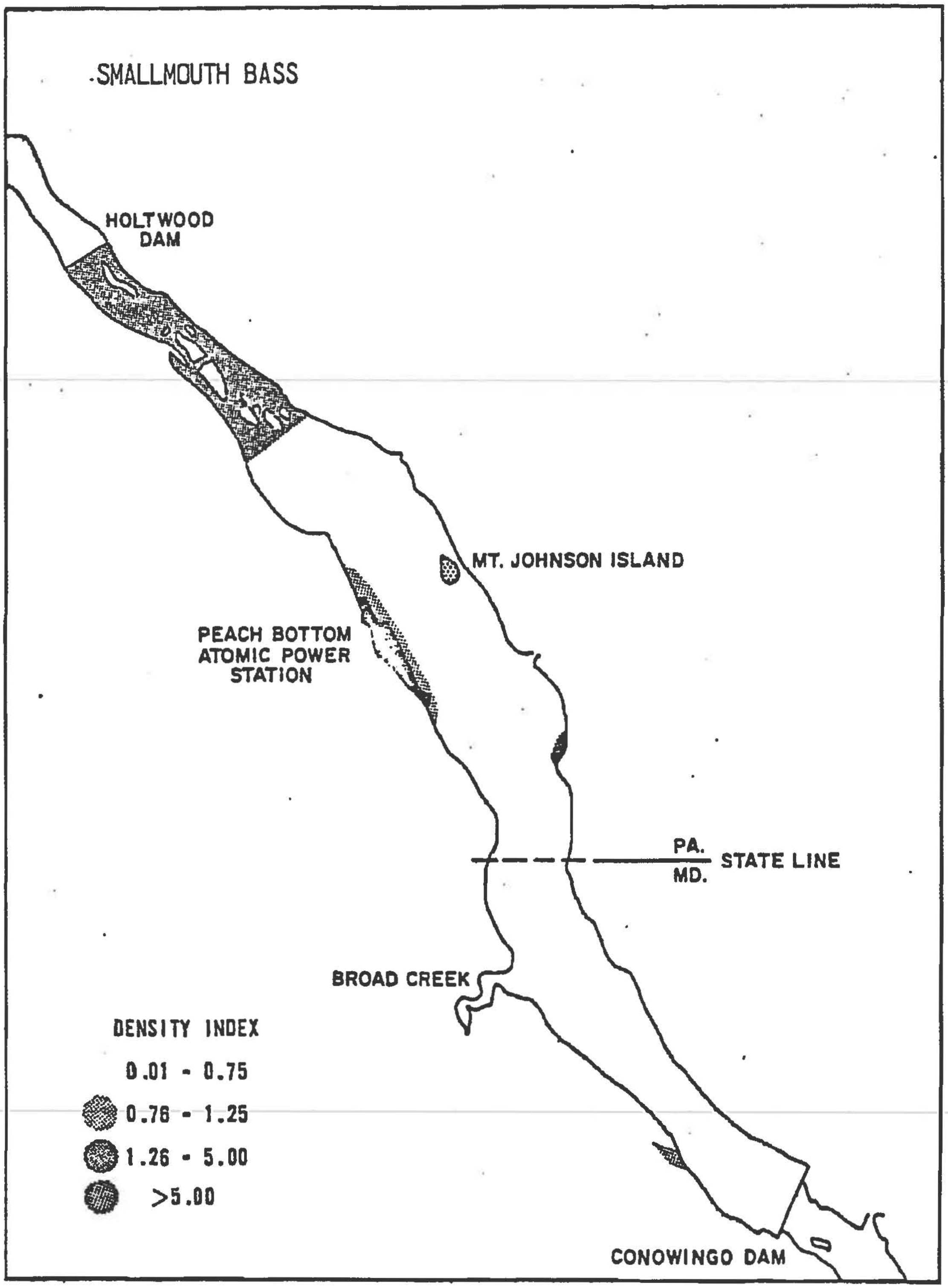

Figure 2.3-5

Location of spawning areas of the smallmouth bass, Conowingo Pond.

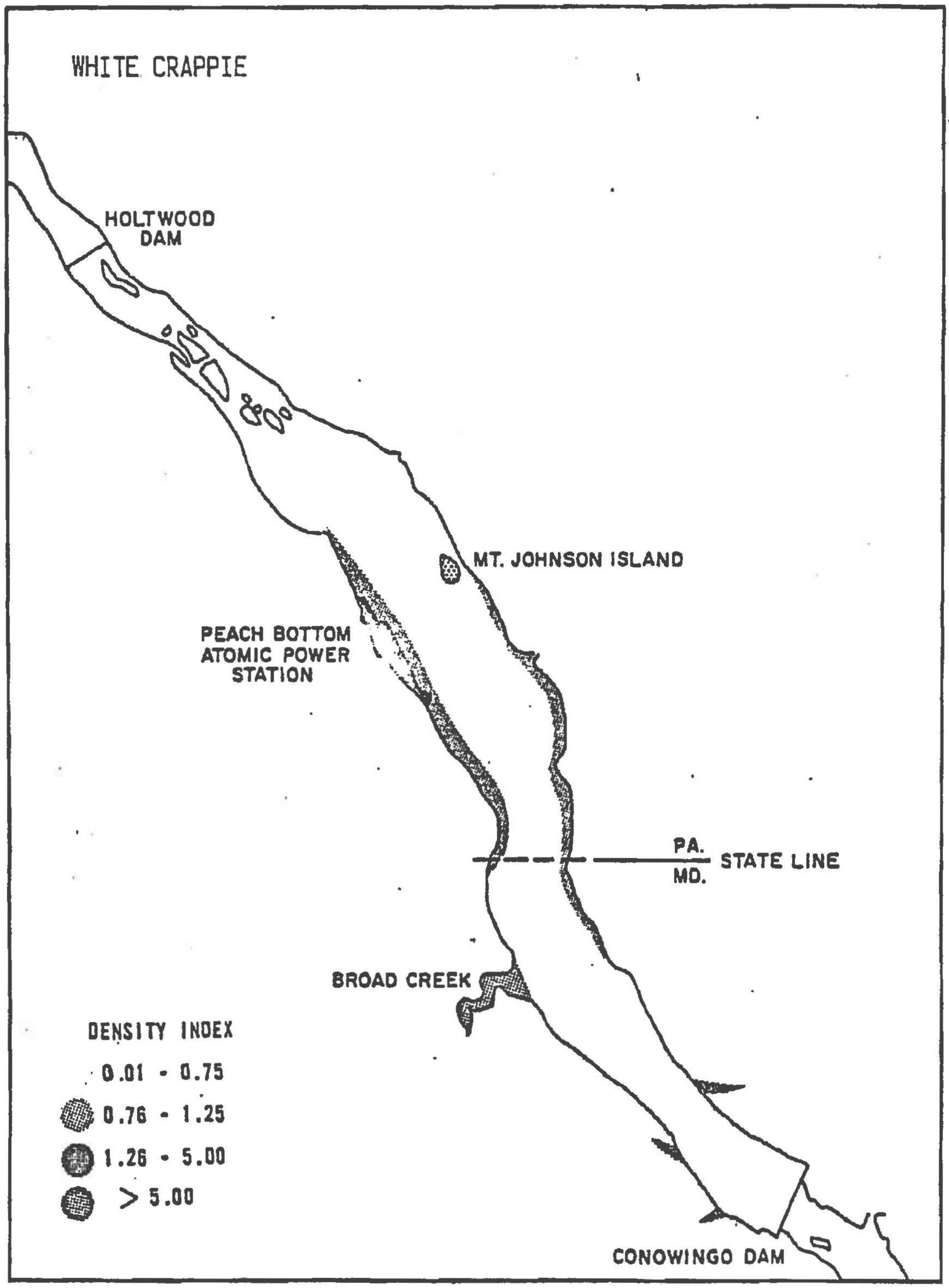

Figure 2.3-6

Location of spawning areas of the white crappie, Conowingo Pond.

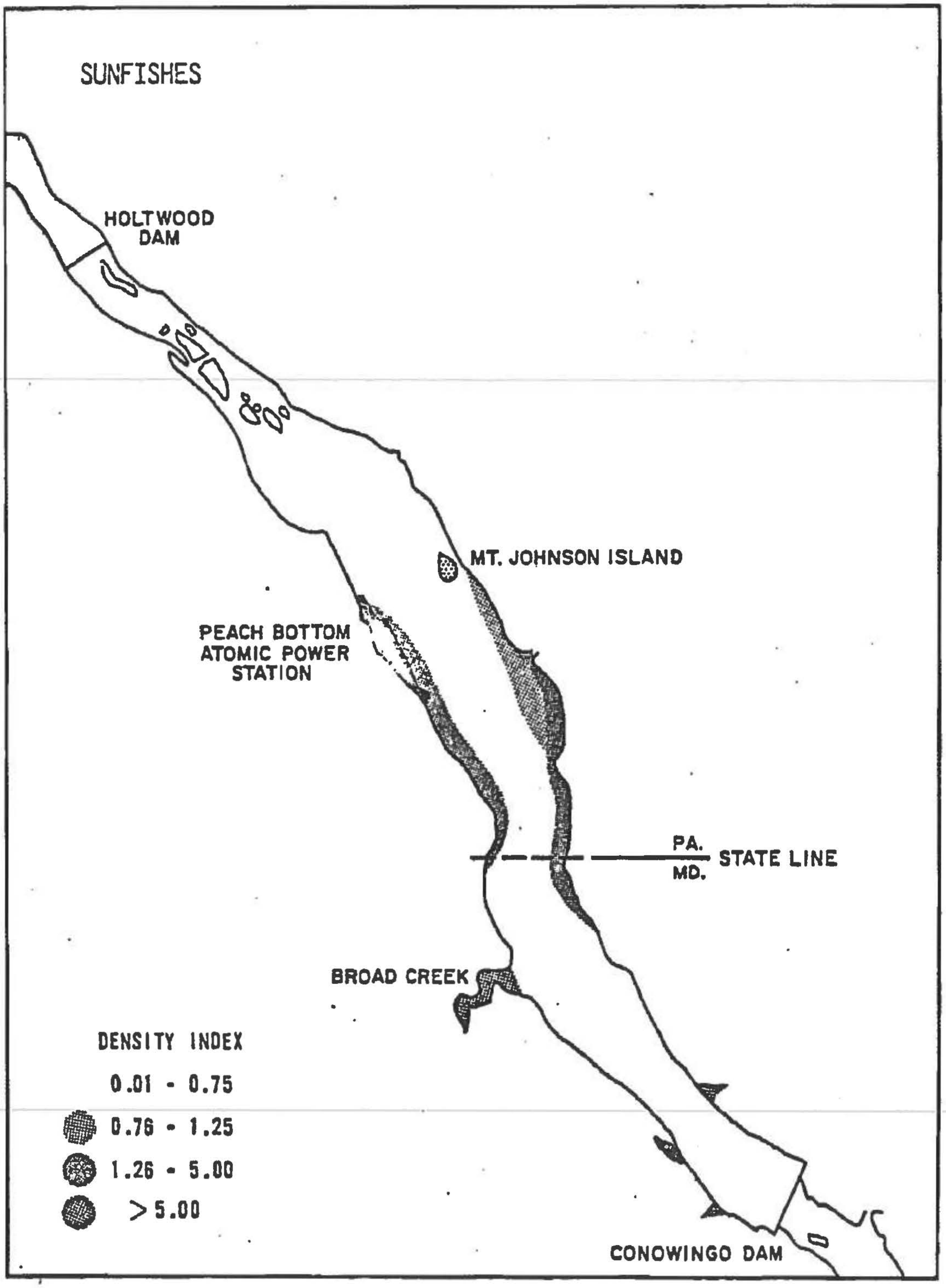

Figure 2.3-7

Location of spawning areas of the sunfishes (bluegill and pumpkinseed), Conowingo Pond.

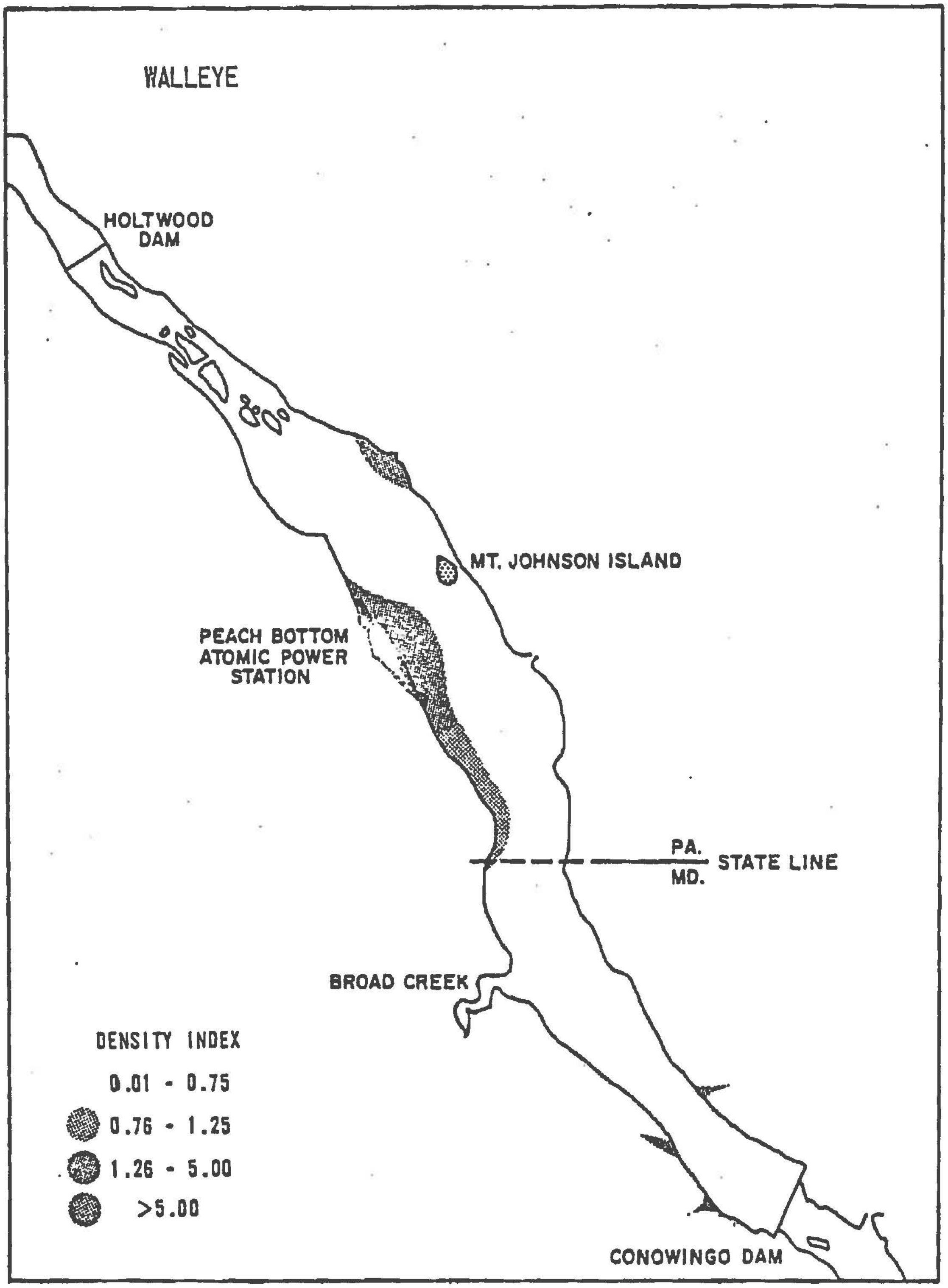

Figure 2.3-8

Location of spawning areas of the walleye, Conowingo Pond.

3.0 IMPINGEMENT STUDIES

3.1 METHODS

Fish samples at traveling intake screens for Unit No. 2 were collected twice a week from November 1973 through December 1976. From July through September 1974 sampling frequency was increased to four 12-hr samples a week to comply with the Environmental Technical Specifications (NRC, 1973). Weekly sampling at Unit No. 3 commenced in December 1974. Screens were surveyed for impinged fishes during two successive 12-hr periods (day and night). Prior to the start of each survey the screens were washed for about 15 minutes. Then a removable aluminum basket with a mesh size of 5/16 in. was placed in a trash bin that receives the screen wash. Fishes which accumulated in the basket constituted a sample.

During the start-up tests of Peach Bottom not all circulating water pumps were in service. Pumps were occasionally operated at the request of IA to determine impingement during maximum water intake. After Peach Bottom began commercial operation all six circulating water pumps were usually in service. Occasionally, samples could not be taken due to mechanical problems and/or accumulation of trash.

Fishes were identified, measured and weighed. Total number and weight were estimated from a random subsample when a large number of fishes was impinged. Intake water temperature, average Pond elevation, number of circulating water pumps in operation, average daily river flow, time of day and date were recorded with each sample.

3.2 RESULTS

3.2.1 Species Composition and Frequency of Impingement

In 240 samples of 12-hr duration 16,859 fish (total weight 197 kg or 433 lb) of 37 species were impinged at the screens for Unit No. 2 from November 1973 through December 1976 (Table 3.2-1). At Unit No. 3 between December 1974 and December 1976 some 42,088 specimens (total weight 1173 kg or 2580 lb) of 35 species were impinged in 137 samples (Table 3.2-2). The species composition of impinged fishes at both units were similar. Many species were rarely impinged and occurred in less than 10% of the samples. Of the 37 species impinged at Unit No. 2, the rate of impingement of 31 species (84%) averaged less than 1.0 fish/12-hr. At Unit No. 3, 20 species (57%) were impinged for an average of less than 1.0 fish/12-hr. Data for both units are summarized in Table 3.2-3 .

The channel catfish, white crappie and bluegill were impinged most frequently at both units (Tables 3.2-1 and 3.2-2). Most of these fishes were small and averaged less than 120 mm in length (Tables 3.2-4 and 3.2-5). These fishes comprised 82% by number and 73% by weight of the total catch at Unit No. 2 and 78% by number and 84% by weight at Unit No. 3. The channel catfish was the most frequently impinged fish and occurred in 97% of the samples at Unit No. 2 and 99% of the samples at Unit No. 3. It formed the bulk of the biomass at Unit No. 3. The white crappie composed most of the biomass at Unit No. 2. The carp, although impinged infrequently and in low numbers, comprised 16% of the biomass at Unit No. 2. Game fishes such as the smallmouth bass, largemouth bass, walleye and muskellunge were rarely impinged, particularly at Unit No. 2. Most of the yellow perch and smallmouth bass at Unit No. 3 were impinged during two days of high river flows in February 1975. The gizzard shad which was accidentally introduced into the Pond in 1972, was seldom impinged.

The rate of impingement of the common fishes (channel catfish, white crappie and bluegill) differed considerably between months (Figures 3.2-1 and 3.2-2). Impingement of the white crappie and bluegill was highest in November through February and negligible in March through October. The impingement of the channel catfish was highest in November through April. However, in 1975 a large number of channel catfish was impinged in June through September. The impingement of the channel catfish was consistently higher than that of bluegill or white crappie. In most months the impingement of fishes was greater at Unit No. 3 than at Unit No. 2.

Since two distinct periods of impingement were evident, the data were pooled into high impingement (November through April) and low impingement (May through October) periods. The day-night differences were then examined (Tables 3.2-6 and 3.2-7). The data shown are only for the channel catfish; similar analyses were run for the white crappie and bluegill. Little difference existed between day and night samples between periods although the impingement appeared to be slightly higher at night. Impingement increased when river flows were greater than 200,000 cfs, regardless of time. When data obtained above the latter flow were excluded, a marked change was noted in the basic statistics. For example, in May through October at Unit No. 2 the number of channel catfish impinged during the day averaged 36 per 12-hr (with a coefficient variation of 438%) when all samples were included. When the samples during the high river flows were excluded the mean was reduced to 16 per 12-hr (with a coefficient of variation of 102%). Similarly the mean day and night impingement of channel catfish in November through April at Unit No. 3 was reduced from 479 to 57 and 312 to 73 per 12-hr, respectively. The coefficients of variation were reduced from 434 and 397 to 159 and 111%, respectively. Similar reductions were observed for the other species. These differences were

more pronounced at Unit No. 3 than at Unit No. 2 and for the channel catfish than for the bluegill and white crappie.

The channel catfish was most frequently impinged; however only in 31% of the samples taken at Unit No. 2 were more than 25 catfish impinged per 12-hr period (Table 3.2-8). An impingement of greater than 200 catfish per 12-hr occurred in only 2% of the samples. The impingement of bluegill and white crappie was more than 25 specimens per 12-hr in only 8 and 6% of the samples, respectively. The rate of impingement of the channel catfish at Unit No. 3 was more than 25 fish per 12-hr in 39% of the samples. The impingement of the white crappie and bluegill at Unit No. 3 was like that at Unit No. 2. The number of these two fishes impinged rarely exceeded 50 fish per 12-hr.

The impingement of fishes differed with the operating conditions at Peach Bottom. For example, high impingement at Unit No. 2 (particularly of the channel catfish) occurred during the early part of the sampling program when Peach Bottom was partially operational and circulating water pumps were operated at the request of I A. Of the first 34 samples taken at Unit No. 2 during the start-up phase in winter, 24 samples (71%) contained more than 25 channel catfish per 12-hr and 20 (59%) contained more than 50 fish per 12-hr. It is likely that the fishes concentrated in the vicinity of the screens prior to the start-up and thus were more vulnerable to impingement, particularly in winter. This became apparent when the 206 samples taken subsequent to the initial 34 were examined. Of these, 52 samples (22%) contained more than 25 channel catfish per 12-hr and 5% contained more than 50 channel catfish per 12-hr. The same pattern was observed for the white crappie and bluegill, although the numbers were lower. This pattern was also observed during the start-up of Unit No. 3.

3.2.2 Statistical Analysis

Although some loss was expected due to the operation of the Peach Bottom, we have attempted to isolate Peach Bottom operational factors from environmentally related factors or conditions that may modify impingement. The relationship between number of fish impinged and physical factors was examined. The data on the number of fish impinged (log Y+1) per 12-hr period were analyzed by stepwise multiple regression. The independent variables (X_i) were water temperature, daily river flow (obtained from Holtwood Dam), number of circulating water pumps in operation, Pond elevation, time of day, week after unit commenced operation and season. The number of each species impinged was the dependent (Y) variable. Models containing the various interactions of the independent variables were also developed. However, in most cases the simple models (without interactions) were equally informative. Therefore the simple models are discussed. The analysis was run separately for the channel catfish, white crappie and bluegill and total number of fish impinged at Units No. 2 and 3. All data were used in the analysis.

Together the average daily river flow, week and Pond elevation accounted for 26% of the variation (R^2) in the impingement rate of the channel catfish at Unit No. 2 (Table 3.2-9). A total of 60% of the variation (R^2) was accounted for at Unit No. 3 by week, average daily river flow and temperature. Season was the factor which most affected the impingement rate of white crappie at both units. River flow and Pond elevation were important in affecting the impingement rate of the bluegill.

When the data for all fish combined were examined, the daily river flow, Pond elevation and season were found to be significant factors at Unit No. 2.

Daily river flow was also most important at Unit No. 3 but Pond elevation and season were replaced by week and temperature.

The percent variation (R^2) explained by the factors examined at the two units differed considerably. For example, for all fishes 68% of the variation was explained at Unit No. 3, but only 39% at Unit No. 2. Differences of similar magnitude were also observed for the channel catfish and bluegill, but more variation (R^2) was explained at Unit No. 2 than No. 3 for the white crappie. The reason, in part, for these differences is the greater number of observations taken at Unit No. 3 at river flows in excess of 200,000 cfs than at Unit No. 2. It should be noted that a large portion of the variation (R^2), particularly at Unit No. 2, is unexplained.

In all the analyses the sign of the regression coefficient indicated that the impingement rates increase with (1) an increase in river flow, (2) decrease in water temperature and (3) lowering of the Pond elevation. Impingement was higher in the winter at the time of high river flows and low water temperatures. Impingement was also higher on occasions when the Pond elevation was lowered about five feet below the mean normal elevation of 108 ft (Conowingo datum).

The analysis showed that time of day and number of circulating water pumps did not substantially affect the rate of impingement. Six circulating water pumps were usually in operation when the samples were taken; however, less were operated in early 1974 and occasionally when a unit was not at full power. Under normal operating conditions one would not expect the number of pumps to substantially affect the impingement of fishes because this variable was more or less constant during most of the sampling period. The sign of the regression coefficient for the variable "pump" was positive and indicanted that impingement may increase with an increase in the number of pumps operating. However, inclusion of these variables in this analysis did not

significantly improve the R^2 value or reduce the standard error. Therefore the inclusion of the two variables time of day and number of pumps in the present analysis is of doubtful significance in assessing the impingement rate.

Intake design may be a major factor involved in low impingement rates at some power stations. The impingement rate at Peach Bottom was negligible. The design of the screens at Peach Bottom was based on the knowledge of the difficulties which were experienced elsewhere and the swimming speed of fishes in Conowingo Pond. The criteria for the design at Peach Bottom were as follows: (1) a mesh of 3/8 in. was used in the vertical traveling screens; (2) upstream and downstream escape routes were provided for fishes; (3) the screens were continguous with the shore so that no trap was formed in front of the screens; and (4) the approach velocity of the water was reduced in front of the screens to 0.75 fps at a low water stage (104.5 ft Conowingo datum). Studies were done on swim speed of resident fishes by IA (Hocutt, 1973 and King, 1969) to determine the criteria of 0.75 fps in front of the screens.

3.2.3 Project Losses

The total monthly losses in number, weight and volume of fishes due to impingement were projected from mean number, weight and volume of fishes impinged at screens for Units No. 2 and 3 (Tables 3.2-10 to 3.2-13). The monthly means were multiplied by the corresponding number of 12-hr periods in a month to estimate the total losses for the month. The calculations were made only for the period June 1974, when Unit No. 2 began commercial

operation, through December 1976. An example of the calculations is given at the bottom of Table 3.2-10. Of 1,526 possible 12-hr periods in June 1974 through December 1976, 184 (12%) were sampled at Unit No. 2. Some 9% (137 of 1,462 periods) were sampled at Unit No. 3 between December 1974 (beginning of commercial operation) and December 1976. Projected losses were not calculated for months in which samples were not taken. due to unit shutdown or mechanical problems. The estimates were made (1) including the data obtained during the high river flows (> 200,000 cfs) and (2) excluding them. The impingement increased substantially at high river flows (see Section 3.2.1). It must be noted that the estimates contain projections for continuous operation of Peach Bottom since June 1974. However, Peach Bottom did not operate consistently throughout the sampling period thus the estimates shown in Tables 3.2-10 to 3.2-13 are considered conservative (high in some months).

The estimated losses of fishes exceeded 100 kg (220 lb) only in seven months (excluding high flows) for Units No. 2 and 3 combined. Most of the projected monthly losses were less than 50 kg (110 lb) particularly at Unit No. 2. Sections 4.1 of the Environmental Technical Specifications for Peach Bottom states that the number, size and species of fish impinged should be determined if more than 4 ft^3 of fish are collected in a single 12-hr period. This level was exceeded only in February 1975 at Unit No. 3. The high (322 ft^3) projected loss for February 1975 at Unit No. 3 occurred at river flows in excess of 300,000 cfs which prevailed over a period of 2 to 3 days. These conditions inflated the projected loss for the month. If the samples taken at high river flows are excluded the total loss for February 1975 would be reduced from 322 ft^3 to 4.9 ft^3. Based on these data it is

believed that the impingement at Peach Bottom is of potentially low impact and the design of the intake structure is consistent with the concept of best technology available for minimizing adverse environmental impact.

Peach Bottom is not located in an area of unique biological value. The vicinity of the intake structure does not represent either the primary spawning or nursery area. Fishes feed throughout the Pond and thus no specific areas for feeding exist. No rare and endangered species occur in the Pond. No commercially important fish or shellfishes reside in Conowingo Pond. The fishery is primarily for the white crappie and is extensive in the lower portion of the Pond in winter. The white crappie moves seasonally in the Pond (Robbins and Mathur, 1974) but does not concentrate in front of the screens at any season.

3.2.4 Impact of Impingement

Since the population estimates of fishes, particularly in large ponds and reservoirs, show extremely wide confidence intervals and thus are rarely reliable, the impact of impingement of fishes at cooling water intakes of power plants may be measured on a relative basis, such as angler or commercial harvest. If reliable population estimates are not available, it is not possible to determine what percentage of the total fish population is lost due to impingement.

The impact of impingement at the Peach Bottom is quantified on a relative basis. Peach Bottom acts as a predator and the magnitude of predation varies with season. Thus, the impingement loss may be considered as fishing mortality and compared with that of angling mortality (Table 3.2-14).

The angling mortality data used here were obtained from a creel census conducted in 1973 through 1976 by I A to determine the extent of the winter fishery (December-March) in Conowingo Pond. Creel census data were not taken in other months in the present study, but Plosila (1961) conducted a creel census on Conowingo Pond from April through October in 1958, 1959 and 1960.

From the winter fishery survey conducted by IA it was determined that more than 28,600 anglers fished the Pond in the winter of 1974, 1975 and 1976. They fished an average of five hours per trip. The average angler fishing time was multiplied by the catch per hour to obtain the daily harvest per angler. The average daily (5 hr period) harvest was then compared to the average daily impingement (24 hr period) of Peach Bottom (Table 3.2-14). The fishes removed by Peach Bottom were much smaller in length than those kept by anglers (Robbins and Mathur, 1976a). Also, since most of the fishes taken at Peach Bottom were young, only a relatively small percentage would have grown to a harvestable size. Because adjustment for natural mortality was not made, the number of fish harvested by Peach Bottom is conservative.

The average daily catch of white crappie by an angler fishing in December, January, February and March 1974 through 1976 ranged from 1.3 to 19.2. The Peach Bottom harvest ranged from 0.4 to 386.0 for the same time period. The maximum harvest occurred in December 1974; less than 60 fish were taken per day on all other occasions. In all but two months the daily harvest at Peach Bottom was less than that of five fishermen.

The daily harvest of bluegill was higher at Peach Bottom than that of an angler for several seasons. First, Unit No. 3 was in a start-up phase in late December 1974 and January 1975 and it is likely that a concentration of bluegill occurred in front of the screens. Secondly, the exceptionally high exploitation by Peach Bottom in January and February

(Table 3.2-14) occurred when either the river flows were high or the Pond elevation was substantially lowered (see Statistical Analysis). The latter two conditions occurred only over a period of 2 to 3 days. However, the 1976 data indicate that impingement has declined considerably; less than 2 fish were taken per day. As of 1976 the impact was equal to that of one fisherman.

Few channel catfish are taken by anglers during the winter because its activity (vulnerability) decreases at water temperatures less than 50 F. The channel catfish population in Conowingo Pond is stunted and few large fish are available (Robbins and Mathur, 1974). However, it may be pointed out that the 1975 (postoperational) year class of channel catfish was the strongest and about 43 times more abundant than the weakest 1967 (preoperational) year class (Robbins and Mathur, 1976a).

Creel census data on white crappie, bluegill and channel catfish from other seasons are not available for 1974 through 1976. However, data gathered by Plosila (1961) in April through October 1958 to 1960 may be examined to identify the broad trends of the fishery in Conowingo Pond. His data were obtained 17 to 19 years ago. Plosila's (1961) data adjusted for 5 hour fishing trip for the catfishes, sunfishes and crappies are shown in Table 3.2-10. Plosila did not distinguish the catch rates between species of the same genus; consequently, the data shown herein are for groups of fishes, viz. catfishes, crappies and sunfishes.

The data indicate that the number of crappies and sunfishes taken by both angler and Units No. 2 and 3 is low from April through October. Peach Bottom exploited crappies and sunfishes at a rate slightly more than a single angler in most months. The data show that in general the impingement is lower in summer than in winter, as is the angler exploitation. The

exploitation of the catfish population by Peach Bottom was much higher than that of a single angler throughout the year. However, as indicated above channel catfish is not fished extensively relative to its abundance in the Pond. The additional fishing mortality on the channel catfish population attributable to Peach Bottom is not expected to have a detrimental effect because removal of a segment of this stunted population may even benefit its growth rate.

TABLE 3.2-1

Frequency of occurrence, total number, weight and percentage composition of fishes impinged in two hundred-forty 12-hr periods at the Peach Bottom Station Unit No. 2, November 1973-December 1976.

Species	Frequence of Occurrence	Total No.	Mean No.	% No.	Total Wt. (kg)	Mean Wt. (kg)	% Wt.
American eel	1	2	*	*	2.19	0.01	1.3
American shad	5	5	*	*	0.03	**	*
Alewife	2	2	*	*	0.01	**	*
Gizzard shad	45	675	2.8	4.0	7.23	0.03	3.8
Muskellunge	2	13	*	*	0.33	**	*
Carp	29	96	0.4	0.6	30.76	0.13	16.5
Golden shiner	5	7	*	*	0.05	**	*
Comely shiner	14	14	0.1	0.1	0.09	**	*
Spottail shiner	31	121	0.5	0.7	0.87	**	0.4
Shallowtail shiner	1	2	*	*	0.01	**	*
Rosyface shiner	1	12	*	*	0.04	**	*
Spotfin shiner	35	238	0.9	1.4	0.50	**	0.3
Bluntnose minnow	1	1	*	*	0.01	**	*
Fathead minnow	1	1	*	*	**	**	*
Blacknose dace	1	1	*	*	**	**	*
Quillback	4	5	*	*	0.59	**	0.3
White sucker	1	1	*	*	0.01	**	*
Northern hogsucker	1	1	*	*	**	**	*
Shorthead redhorse	1	1	*	*	0.01	**	*
White catfish	17	17	0.1	0.1	0.98	**	0.5
Yellow bullhead	44	83	0.3	0.5	1.51	0.01	0.8
Brown bullhead	8	8	*	*	0.10	**	*
Channel catfish	232	8070	33.6	47.9	58.40	0.24	29.7
Margined madtom	1	1	*	*	0.01	**	*
Mummichog	2	2	*	*	0.01	**	*
Rock bass	4	4	*	*	0.04	**	*
Redbreast sunfish	23	366	1.5	2.2	1.19	**	0.6
Green sunfish	26	180	0.8	1.1	0.86	**	0.4
Pumpkinseed	62	743	3.1	4.4	2.13	0.01	1.1
Bluegill	94	3686	15.4	21.9	19.12	0.08	9.7
Smallmouth bass	12	17	0.1	0.1	0.82	**	0.4
Largemouth bass	13	47	0.2	0.3	0.40	**	0.2
White crappie	119	2136	8.9	12.7	66.08	0.28	33.6
Black crappie	26	51	0.2	0.3	1.04	**	0.5
Tessellated darter	33	188	0.8	1.1	0.24	**	0.1
Yellow perch	9	60	0.3	0.4	0.64	**	0.3
Walleye	2	2	*	*	0.57	**	0.3
Totals		16,859	70.2		196.87	0.82	

* Less than 0.1
** Less than 0.01

TABLE 3.2-2

Frequency of occurrence, number, weight and percentage composition of fishes impinged in one hundred thirty-seven 12-hr periods at the Peach Bottom Station Unit No. 3, December 1974-December 1976.

Species	Frequence of Occurrence	Total No.	Mean No.	% No.	Total Wt. (kg)	Mean Wt. (kg)	% Wt.
American eel	2	2	*	*	3.490	0.03	0.3
American shad	2	2	*	*	0.009	**	*
Alewife	2	2	*	*	0.007	**	*
Gizzard shad	44	235	1.7	0.6	3.229	0.02	0.3
Muskellunge	2	19	0.1	*	0.924	0.01	0.1
Goldfish	1	1	*	*	0.255	**	*
Carp	12	80	0.6	0.2	21.856	0.16	1.9
Riverchub	3	4	*	*	0.024	**	*
Golden shiner	11	48	0.4	0.1	0.220	**	*
Comely shiner	10	141	1.0	0.3	0.478	**	*
Spottail shiner	30	2438	17.8	5.8	15.239	0.11	1.3
Swallowtail shiner	1	1	*	*	0.002	**	*
Rosyface shiner	1	36	0.3	*	0.180	**	*
Spotfin shiner	24	116	0.8	0.3	0.458	**	*
Bluntnose minnow	6	8	*	*	0.029	**	*
Quillback	9	116	0.8	0.3	4.296	0.03	0.3
White sucker	7	343	2.5	0.8	1.742	0.01	0.1
Shorthead redhorse	1	126	0.9	0.3	1.908	0.01	0.2
White catfish	10	10	0.1	*	0.518	**	*
Yellow bullhead	26	249	1.8	0.6	3.173	0.02	0.3
Brown bullhead	20	462	3.4	1.1	51.033	0.37	4.3
Channel catfish	136	26,966	196.8	64.1	921.165	6.72	78.5
Margined madtom	2	3	*	*	0.014	**	*
Rock bass	14	106	0.8	0.2	0.658	**	*
Redbreast sunfish	26	673	2.7	1.6	3.965	0.03	0.3
Green sunfish	12	421	3.1	1.0	3.087	0.02	0.3
Pumpkinseed	41	1135	8.3	2.7	6.112	0.04	0.5
Bluegill	53	4820	35.2	11.5	36.485	0.27	3.1
Smallmouth bass	28	554	4.0	1.3	5.070	0.04	0.4
Largemouth bass	9	69	0.5	0.1	0.491	**	**
White crappie	71	1070	7.8	2.5	30.657	0.22	2.6
Black crappie	17	53	0.4	0.1	1.102	**	**
Tessellated darter	24	632	4.6	1.5	1.247	**	0.1
Yellow perch	9	1146	8.4	2.7	53.811	0.39	4.5
Log perch	1	1	*	*	0.011	**	*
Totals		42,088	307.2		1172.945	8.56	

* Less than 0.1
** Less than 0.01

TABLE 3.2-3

Frequency of occurrence, number and weight of fishes impinged in three hundred seventy-seven 12-hr periods at the Peach Bottom Station Units No. 2 and 3, December 1974-December 1976.

Species	Freq.	Total No.	Mean No.	% No.	Total Wt.	Mean Wt.	% Wt.
American eel	3	4	*	*	5.68	0.02	0.4
Alewife	4	4	*	*	0.02	**	*
American shad	7	7	*	*	0.04	**	*
Gizzard shad	89	910	2.4	1.5	10.46	0.03	0.8
Muskellunge	4	32	0.1	0.1	1.25	**	0.1
Goldfish	1	1	*	*	0.26	**	*
Carp	41	176	0.5	0.3	52.62	0.14	3.8
River chub	3	4	*	*	0.02	**	*
Golden shiner	16	55	0.1	0.1	0.27	**	*
Comely shiner	24	155	0.4	0.3	0.57	**	*
Spottail shiner	61	2559	6.8	4.3	16.11	0.04	1.2
Swallowtail shiner	2	3	*	*	0.01	**	*
Rosyface shiner	2	48	0.1	0.1	0.22	**	*
Spotfin shiner	59	354	0.9	0.6	0.96	**	0.1
Bluntnose minnow	7	9	*	*	0.04	**	*
Fathead minnow	1	1	*	*	**	**	*
Blacknose dace	1	1	*	*	**	**	*
Quillback	13	121	0.3	0.2	4.89	0.01	0.4
White sucker	8	344	0.9	0.6	1.75	**	0.1
Northern hogsucker	1	1	*	*	**	**	*
Shorthead redhorse	2	127	0.3	0.2	1.92	0.01	0.1
White catfish	27	27	0.1	*	1.50	**	0.1
Yellow bullhead	70	332	0.9	0.6	4.68	0.01	0.3
Brown bullhead	28	470	1.2	0.8	51.13	0.14	3.7
Channel catfish	368	35036	92.9	59.4	979.56	2.60	71.5
Margined madtom	3	4	*	*	0.02	**	*
Mummichog	2	2	*	*	0.01	**	*
Rock bass	18	110	0.3	0.2	0.70	**	0.1
Redbreast sunfish	49	1039	2.8	1.8	5.15	0.01	0.4
Green sunfish	38	601	1.6	1.0	3.95	0.01	0.3
Pumpkinseed	103	1878	5.0	3.2	8.24	0.02	0.6
Bluegill	147	8506	22.6	14.4	55.60	0.15	4.1
Smallmouth bass	40	571	1.5	1.0	5.89	0.02	0.4
Largemouth bass	22	116	0.3	0.2	0.89	**	0.1
White crappie	190	3206	8.5	5.4	96.74	0.26	7.1
Black crappie	43	104	0.3	0.2	2.14	0.01	0.2
Tessellated darter	57	820	2.2	1.4	1.49	**	0.1
Yellow perch	18	1206	3.2	2.0	54.45	0.14	4.0
Logperch	1	1	*	*	0.01	**	*
Walleye	12	2	*	*	0.57	**	*
Totals		58947	156.2		1369.81	3.62	

* Less than 0.1
** Less than 0.01

TABLE 3.2-4

Mean fork lengths and range of the common fishes impinged at the Peach Bottom Station Unit No. 2, November 1973-December 1976.

Species	1973 Nov	1973 Dec	1974 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White crappie	86 (63-109)	114 (51-240)	138 (61-230)	129 (57-220)	150 (130-170)	95 (91-99)	69	189 (162-211)	99 (48-193)	72 (65-80)	114 (100-129)	109 (79-124)	107 (70-129)	116 (41-230)
Channel catfish	71 (41-274)	62 (41-220)	62 (31-270)	62 (31-297)	64 (31-173)	74 (41-240)	87 (48-245)	98 (51-214)	119 (35-225)	94 (38-300)	93 (31-280)	97 (43-176)	72 (48-129)	78 (41-130)
Bluegill	54 (43-83)	69 (31-180)	77 (39-161)	82 (41-207)	69 (59-79)	58 (40-89)	52	-	-	-	54 (35-64)	53 (45-70)	58 (44-105)	70 (41-170)

Species	1975 Jan	Feb	Mar	Jun	Jul	Aug	Sep	Oct	Dec
White crappie	126 (80-242)	192 (103-252)	106 (78-133)	-	143 (135-151)	174 (160-204)	187 (93-250)	78 (51-170)	154 (71-230)
Channel catfish	84 (21-220)	85 (41-243)	91 (41-170)	96 (41-220)	113 (41-190)	79 (31-230)	78 (41-210)	74 (41-200)	97 (31-230)
Bluegill	74 (41-185)	68 (41-90)	107 (47-171)	79 (52-106)	62	-	50 (28-78)	58 (31-140)	109

Species	1976 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White crappie	163 (81-221)	-	-	-	-	-	-	202 (201-204)	-	83 (38-192)	95 (61-210)	108 (65-186)
Channel catfish	111 (41-290)	75 (41-200)	71 (41-196)	-	-	-	80 (36-178)	80 (31-210)	85 (31-230)	62 (31-200)	76 (41-240)	73 (44-184)
Bluegill	-	-	53 (45-61)	-	-	-	45	45 (43-48)	51 (40-65)	56 (31-180)	91 (40-140)	-

TABLE 3.2-5

Monthly mean fork lengths and range of the common fishes impinged at the Peach Bottom Station Unit No. 3, December 1974-December 1976.

Species	1974	1975											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White crappie	122 (31-240)	127 (91-230)	153 (102-221)	107 (78-139)	143 (99-243)	176 (129-223)	163 (125-220)	175 (161-208)	166	-	61 (50-77)	72 (64-90)	146 (56-270)
Channel catfish	90 (41-260)	75 (41-150)	87 (31-250)	96 (41-200)	107 (31-232)	109 (41-210)	109 (51-213)	112 (41-210)	84 (41-202)	106 (51-131)	79 (57-150)	94 (51-160)	107 (41-270)
Bluegill	72 (31-170)	63 (31-110)	62 (31-120)	75 (40-184)	63 (51-85)	66 (48-136)	62 (44-92)	-	-	-	52 (42-61)	67 (45-94)	74 (48-104)

Species	1976											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White crappie	-	154 (147-161)	71 -	254 -	-	168 (150-195)	202 -	216 (182-255)	127 (76-227)	82 (51-115)	90 (62-110)	146 (90-202)
Channel catfish	-	90 (41-260)	69 (41-140)	80 (41-160)	107 (54-230)	145 (71-220)	79 (29-158)	80 (31-200)	62 (41-200)	63 (31-200)	65 (47-113)	74 (41-230)
Bluegill	-	-	63	-	-	73	-	55 (35-110)	47 (43-53)	57 (31-160)	72 (52-88)	-

TABLE 3.2-6

Basic statistics for impingement of channel catfish (no./12-hr) at the Peach Bottom Station Unit No. 2, November 1973-October 1976.

Time	Item	November-April		May-October		November-October	
		All Data	High values[a] excluded	All Data	High values[a] excluded	All Data	High values[a] excluded
Day	No.	53	53	64	62	117	115
	Mean	41.7	41.7	36.3	16.1	38.8	27.9
	Std. dev.	60.0	60.0	159.3	16.3	124.1	44.1
	CV (%)	143.7	143.7	438.3	101.6	320.0	158.2
Night	N	51	51	63	63	114	114
	Mean	48.1	48.1	16.9	16.9	30.9	30.9
	Std. dev.	57.1	57.1	17.0	17.0	42.9	42.9
	CV (%)	118.8	118.8	100.6	100.6	139.2	139.2
Overall	N	104	104	127	125	231	229
	Mean	44.8	44.8	26.7	16.5	34.9	29.4
	Std. dev.	58.4	58.4	113.7	16.6	93.2	43.5
	CV (%)	130.2	130.2	425.7	100.7	267.3	148.1

a - Values obtained at river flows > 200,000 cfs

TABLE 3.2-7

Basic statistics for impingement of channel catfish (no./12-hr) at the Peach Bottom Station Unit No. 3, December 1974-October 1976.

Time	Item	November-April		May-October		November-October	
		All Data	High values[a] excluded	All Data	High values[a] excluded	All Data	High values[a] excluded
Day	N	33	31	33	32	66	63
	Mean	479.2	57.3	19.2	17.3	249.2	36.9
	Std. dev.	2080.9	91.0	29.2	27.6	1478.5	69.3
	CV (%)	434.2	158.9	152.6	159.8	593.3	187.4
Night	N	31	29	33	32	64	61
	Mean	312.0	72.8	23.7	22.4	163.4	46.4
	Std. dev.	1237.9	81.1	34.2	33.8	866.8	65.6
	CV (%)	396.7	111.4	144.0	151.1	530.6	141.6
Overall	N	64	60	66	64	130	124
	Mean	398.3	64.8	21.4	19.8	206.9	41.6
	Std. dev.	1713.6	86.0	31.6	30.7	1212.6	67.4
	CV (%)	430.3	132.7	147.5	154.9	585.9	162.1

a - Values obtained at river flows > 200,000 cfs

TABLE 3.2-8

Frequency distribution of the impingement (no./12-hr) of the common fishes at the Peach Bottom Station Units No. 2 and 3, November 1973-December 1976. N represents sample size.

	Number Impinged/12-hr Intervals						
	< 25	>25	>50	>75	>100	>200	>500
				UNIT NO. 2 (N-240)			
White crappie	222	18	7	6	4	1	1
Bluegill	226	14	10	9	6	3	2
Channel catfish	165	75	32	21	15	5	1
				UNIT NO. 3 (N-137)[a]			
White crappie	130	7	5	4	4	1	-
Bluegill	126	11	10	9	9	8	3
Channel catfish	83	54	37	24	18	8	4

a Samples taken December 1974-December 1976

TABLE 3.2-9

Stepwise multiple regression statistics for impingement of fishes (log Y + 1) at the Peach Bottom Station Units No. 2 and 3, November 1973-December 1976.

Unit No. 2			Unit No. 3		
Order of Entry of Variables	R^2*	p**	Order of Entry of Variables	R^2*	p**
			All Fishes		
N = 240			N = 138		
River Flow	0.252	0.0001	River Flow	0.502	0.0001
Pond Elevation	0.346	0.0001	Week	0.652	0.0001
Season	0.393	0.0001	Temperature	0.681	0.0007
			Channel catfish		
N = 240			N = 138		
River Flow	0.171	0.0001	Week	0.446	0.0001
Week	0.225	0.0001	River Flow	0.585	0.0001
Pond Elevation	0.257	0.0017	Temperature	0.603	0.0151
			White crappie		
N = 240			N = 138		
Season	0.266	0.0001	Season	0.233	0.0001
Pond Elevation	0.356	0.0001	Week	0.275	0.0249
River Flow	0.411	0.0001	River Flow	0.288	0.1275
			Bluegill		
N = 240			N = 138		
River Flow	0.370	0.0001	River Flow	0.579	0.0001
Pond Elevation	0.442	0.0001	Pond Elevation	0.627	0.0001

* R^2 - Coefficient of determination
** p - Probability level

TABLE 3.2-10

Monthly sample and total estimated losses of fishes due to impingement at the Peach Bottom Station during commercial operation, June 1974-December 1976.

Month	Unit No. 2 Mean Per 12-hr Period No.	 Wt. (kg)	 Vol. (ft^3)	Unit No. 3 Mean Per 12-hr Period No.	 Wt. (kg)	 Vol. (ft^3)	Units No. 2 and 3 Estimated Losses Per Month No.	 Wt. (kg)	 Vol. (ft^3)
1974									
Jun	16	0.875	0.043	-	-	-	960	52.5	2.6
Jul	16	0.363	0.018	-	-	-	992	22.5	1.1
Aug	10	0.171	0.008	-	-	-	620	10.6	0.5
Sep	31	0.374	0.018	-	-	-	1860	22.4	1.1
Oct	9	0.130	0.006	-	-	-	558	8.1	0.4
Nov	34	0.280	0.014	-	-		2040	16.8	0.8
Dec	96	1.725	0.085	319	6.955	0.344	25730	538.1	26.6
1975									
Jan	72	0.790	0.039	135	1.374	0.068	12834	134.7	6.6
Feb	75	0.730	0.036	244	1.726	0.085	16856	137.6	6.8
Mar	34	0.346	0.017	168	1.893	0.094	12524	127.5	6.9
Apr	-	-	-	142	1.826	0.090	8520	109.6	5.4
May	-	-	-	94	1.243	0.061	5828	77.1	3.8
Jun	42	0.566	0.028	26	0.642	0.032	4080	72.5	3.6
Jul	46	0.944	0.047	36	0.896	0.044	5084	114.1	5.6
Aug	31	0.470	0.023	27	0.334	0.016	3596	49.8	2.4
Sep	28	0.502	0.025	5	0.104	0.005	1980	36.3	1.8
Oct	37	0.273	0.014	13	0.210	0.010	3100	29.9	1.5
Nov	-	-	-	18	0.200	0.010	1080	12.0	0.6
Dec	18	0.433	0.021	36	0.963	0.048	3348	86.5	4.3
Feb*	-	-	-	3557	116.367	5.750	199192	6516.6	322.0
Sep*	478	2.499	0.123	713	4.909	0.243	71460	444.4	22.0
1976									
Jan	12	0.405	0.020	-	-	-	767	25.1	1.2
Feb	23	0.461	0.022	48	1.060	0.052	4118	88.0	4.3
Mar	10	0.207	0.010	15	0.072	0.004	1552	17.2	0.8
Apr	-	-	-	11	0.111	0.006	682	6.7	0.3
May	-	-	-	5	0.133	0.006	289	8.4	0.4
Jun	-	-	-	4	0.187	0.009	231	11.2	0.6
Jul	6	0.069	0.003	6	0.102	0.005	775	10.7	0.5
Aug	21	0.246	0.012	25	0.356	0.017	2877	37.4	1.8
Sep	12	0.189	0.009	12	0.171	0.008	1440	21.7	1.1
Oct*	128	0.585	0.029	127	0.599	0.029	15856	73.4	3.6
Nov	57	0.574	0.028	16	0.120	0.006	4412	41.7	2.1
Dec	155	1.418	0.070	75	0.979	0.048	14260	148.6	7.2
	Unweighted Means			Unweighted Means			Totals		
Without High Flows	37.1	0.522	.026	64.3	0.942	0.046	142993	2075.3	102.7
With High Flows	57.6	0.601	.030	226.50	5.520	0.273	429501	9109.7	450.3

* Data at river flows > 200,000 cfs

Formula: Monthly estimated losses (number, weight or volume) = Mean number, weight or volume of fishes impinged per 12-hr period at each unit X No. of 12-hr periods in a month.

Example: Losses in December 1974 = No. of fishes = (96x62) + (319x62) = 25730
Wt. (kg) = (1.725x62) + (6.955x62) = 538.1
Vol. (ft^3) = (0.085x62) + (0.344x62) = 26.6

TABLE 3.2-11

Monthly sample and total estimated losses of channel catfish due to impingement at the Peach Bottom Station during commercial operation, June 1974-December 1976.

Month	Unit No. 2 Mean Per 12-hr Period			Unit No. 3 Mean Per 12-hr Period			Units No. 2 and 3 Estimated Losses Per Month		
	No.	Wt. (kg)	Vol. (ft^3)	No.	Wt. (kg)	Vol. (ft^3)	No.	Wt. (kg)	Vol. (ft^3)
1974									
Jun	11	0.182	0.010	-	-	-	660	10.9	0.6
Jul	13	0.323	0.016	-	-	-	806	20.0	1.0
Aug	9	0.158	0.008	-	-	-	558	9.8	0.5
Sep	22	0.316	0.016	-	-	-	1320	19.0	1.0
Oct	6	0.077	0.004	-	-	-	372	4.8	0.2
Nov	16	0.081	0.004	-	-	-	960	4.9	0.2
Dec	20	0.102	0.005	103	0.910	0.045	7626	62.7	3.1
1975									
Jan	44	0.324	0.016	37	0.208	0.010	5022	33.0	1.6
Feb	37	0.325	0.016	115	0.945	0.047	8512	71.1	3.5
Mar	29	0.281	0.014	134	1.498	0.074	10106	110.3	5.5
Apr	-	-	-	132	1.685	0.083	7920	101.1	5.0
May	-	-	-	83	0.978	0.048	5146	60.6	3.0
Jun	31	0.417	0.021	19	0.361	0.018	3000	46.7	2.4
Jul	40	0.708	0.035	31	0.528	0.026	4402	76.6	3.8
Aug	26	0.249	0.012	23	0.260	0.013	3038	31.5	1.5
Sep	23	0.218	0.011	4	0.064	0.003	1620	16.9	0.9
Oct	14	0.107	0.005	5	0.054	0.003	1178	9.9	0.5
Nov	-	-	-	13	0.165	0.008	780	9.9	0.5
Dec	8	0.136	0.007	19	0.411	0.020	1674	33.9	1.6
Feb*	-	-	-	2461	95.633	4.725	137816	5355.4	264.6
Sep*	165	0.992	0.049	50	1.109	0.055	12900	126.0	6.2
1976									
Jan	10	0.272	0.013	-	-	-	589	16.9	0.8
Feb	22	0.147	0.007	45	0.489	0.024	3857	36.9	1.8
Mar	9	0.052	0.003	14	0.053	0.003	1451	6.5	0.4
Apr	-	-	-	11	0.067	0.003	660	4.0	0.2
May	-	-	-	4	0.079	0.004	248	4.9	0.2
Jun	-	-	-	2	0.092	0.005	120	5.5	0.3
Jul	5	0.062	0.003	5	0.058	0.003	632	7.5	0.4
Aug	20	0.207	0.010	23	0.239	0.012	2678	7.5	1.3
Sep	11	0.149	0.007	9	0.102	0.005	1176	27.6	0.7
Oct*	34	0.139	0.006	7	0.037	0.002	2548	15.0	0.5
Nov	9	0.078	0.004	4	0.017	0.001	756	10.9	0.3
Dec	14	0.118	0.006	31	0.285	0.014	2759	25.0	1.3
	Unweighted Means			Unweighted Means					
Without High Flows	13.1	0.209	0.010	55.2	0.621	0.031	79626	889.0	44.1
With High Flows	25.3	0.239	0.012	215.3	6.987	0.345	232890	6381.3	315.4

* Data at river flows > 200,000 cfs

TABLE 3.2-12

Monthly sample and total estimated losses of white crappie due to impingement at the Peach Bottom Station during commercial operation, June 1974-December 1976.

Month	Unit No. 2 Mean Per 12-hr Period No.	Unit No. 2 Wt. (kg)	Unit No. 2 Vol. (ft^3)	Unit No. 3 Mean Per 12-hr Period No.	Unit No. 3 Wt. (kg)	Unit No. 3 Vol. (ft^3)	Units No. 2 and 3 Estimated Losses Per Month No.	Units No. 2 and 3 Wt. (kg)	Units No. 2 and 3 Vol. (ft^3)
1974									
Jun	3	0.230	0.011	-	-	-	180	13.8	0.7
Jul	(0.3)	0.010	**	-	-	-	19	0.6	***
Aug	(0.25)	0.001	**	-	-	-	16	0.1	***
Sep	(0.3)	0.007	**	-	-	-	18	0.4	***
Oct	(0.4)	0.010	**	-	-	-	25	0.6	***
Nov	8	0.148	0.007	-	-	-	480	8.9	0.4
Dec	63	1.475	0.073	130	3.680	0.182	11966	319.6	15.8
1975									
Jan	9	0.271	0.013	24	0.745	0.037	2046	63.0	3.1
Feb	2	0.220	0.011	1	0.102	0.005	168	18.0	0.9
Mar	1	0.027	0.001	2	0.030	0.001	186	3.6	0.2
Apr	-	-	-	1	0.035	0.002	30	2.1	0.1
May	-	-	-	(0.3)	0.031	0.002	20	1.9	0.1
Jun	0	0.000	0.000	1	0.077	0.004	60	4.6	0.2
Jul	1	0.040	0.002	1	0.091	0.004	124	8.1	0.3
Aug	1	0.106	0.005	(0.3)	0.016	0.001	78	7.6	0.4
Sep	2	0.236	0.012	0	0.000	0.000	120	14.2	0.7
Oct	6	0.042	0.002	3	0.010	**	558	3.2	0.1
Nov	-	-	-	2	0.009	**	120	0.5	***
Dec	4	0.232	0.011	8	0.411	0.020	744	39.9	1.9
Feb*	-	-	-	13	0.208	0.010	1020	11.6	0.6
Sep*	7	0.205	0.010	17	0.138	0.007	1148	20.6	1.0
1976									
Jan	1	0.092	0.005	-	-	-	62	5.7	0.3
Feb	0	0.000	0.000	1	0.025	0.001	29	1.4	0.1
Mar	0	0.000	0.000	(0.2)	0.001	**	12	0.1	***
Apr	-	-	-	(0.1)	0.026	0.001	6	1.5	0.1
May	-	-	-	0	-	-	0	0.0	0.0
Jun	-	-	-	(0.4)	0.026	0.001	24	1.5	0.1
Jul	0	0.000	0.000	(0.2)	0.019	0.001	12	1.2	0.1
Aug	(0.2)	0.022	0.001	1	0.083	0.004	49	6.5	0.4
Sep	0	0.000	0.000	1	0.032	0.002	30	1.9	0.1
Oct*	6	0.036	0.002	4	0.030	0.002	583	4.0	0.2
Nov	10	0.116	0.006	3	0.027	0.001	762	8.5	0.4
Dec	4	0.003	**	4	0.214	0.011	465	13.5	0.7
	Unweighted Means			Unweighted Means					
Without High Flows	4.8	0.137	0.006	8.0	0.232	0.011	18409	552.5	27.0
With High Flows	5.0	0.136	0.006	8.3	0.220	0.010	21160	588.7	28.2

* Data at river flows ≥ 200,000 cfs
** Less than 0.001
*** Less than 0.1

TABLE 3.2-13

Monthly sample and total estimated losses of bluegill due to impingement at the Peach Bottom Station during commercial operation, June 1974-December 1976.

Month	Mean Per 12-hr Period No.	Wt. (kg)	Vol. (ft^3)	Mean Per 12-hr Period No.	Wt. (kg)	Vol. (ft^3)	Estimated Losses Per Month No.	Wt. (kg)	Vol. (ft^3)
1974									
Jun	0	0.000	0.000	-	-	-	0	0.0	0.0
Jul	0	0.000	0.000	-	-	-	0	0.0	0.0
Aug	0	0.000	0.000	-	-	-	0	0.0	0.0
Sep	1	0.005	**	-	-	-	60	0.3	***
Oct	1	0.004	**	-	-	-	62	0.2	***
Nov	8	0.035	0.002	-	-	-	480	2.1	0.1
Dec	9	0.107	0.005	59	0.622	0.031	4216	45.2	2.2
1975									
Jan	16	0.160	0.008	60	0.330	0.016	4712	30.4	1.5
Feb	16	0.099	0.005	91	0.460	0.023	5992	31.3	1.6
Mar	(0.6)	0.023	0.001	7	0.132	0.007	471	9.6	0.5
Apr	-	-	-	1	0.004	**	60	0.2	***
May	-	-	-	2	0.016	0.001	124	1.0	0.1
Jun	(0.5)	0.008	**	1	0.005	**	90	0.8	***
Jul	(0.25)	0.001	**	0	0.000	0.000	16	0.1	***
Aug	0	0.000	0.000	0	0.000	0.000	0	0.0	0.0
Sep	1	0.004	**	0	0.000	0.000	60	0.2	***
Oct	13	0.058	0.003	2	0.006	**	930	4.0	0.2
Nov	-	-	-	2	0.021	0.001	120	1.3	0.1
Dec	(0.17)	0.004	**	1	0.006	**	73	0.6	***
Feb*	-	-	-	300	2.876	0.142	16800	161.1	8.0
Sep*	156	0.549	0.027	306	1.310	0.065	27720	111.5	5.4
1976									
Jan	0	0.000	0.000	-	-	-	0	0.0	0.0
Feb	0	0.000	0.000	0	0.000	0.000	0	0.0	0.0
Mar	(0.5)	0.002	**	(0.2)	0.001	**	43	0.1	***
Apr	-	-	-	0	0.000	0.000	0	0.0	0.0
May	-	-	-	0	0.000	0.000	0	0.0	0.0
Jun	-	-	-	(0.1)	0.002	**	6	0.1	***
Jul	(0.1)	**	**	0	0.000	0.000	6	***	***
Aug	(0.5)	0.001	**	(0.6)	0.004	**	68	0.3	***
Sep	(0.6)	0.002	**	(0.7)	0.002	**	78	0.2	***
Oct*	70	0.255	0.013	77	0.308	0.015	9108	34.9	1.7
Nov	1	0.033	0.002	(0.5)	0.004	**	84	2.1	C.1
Dec	0	-	-	0	0.000	0.000	0	0.0	0.0
	Unweighted Means			Unweighted Means					
Without High Flows	2.9	0.024	0.001	9.9	0.070	0.003	17731	130.1	6.4
With High Flows	11.4	0.053	0.002	35.0	0.235	0.012	71379	437.6	21.6

* Data at river flow > 200,000 cfs
** Less than 0.001
*** Less than 0.1

TABLE 3.2-14

Comparison of the average catch per effort of an angler (fishing trip = 5 hr.) and the screens at Peach Bottom (fishing time = 24 hr.). Data collected from 1958 through 1960 and 1974 through 1976.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angler[1]					Crappies							
1958	-	-	-	4.7	3.0	2.5	0.2	0.2	0.4		-	-
1959	-	-	-	4.4	4.7	1.7	0.3	0.3	2.5	2.5	-	-
1960	-	-	-	2.6	1.9	1.3	0.2	0.5	2.0	0.2	-	-
					White crappie							
1974	12.0	19.2	2.3	-	-	-	-	-	-	-	-	5.0
1975	4.4	6.1	1.3	-	-	-	-	-	-	-	-	6.5
1976	10.6	8.8	3.5	-	-	-	-	-	-	-	-	6.6
Average	9.0	11.4	2.4	3.9	3.2	1.8	0.2	0.3	1.6	1.0	-	6.0
Peach Bottom Units No. 2 and 3												
1974[2]	53.0	32.8	0.5	1.0	0.3	12.0	1.2	1.0	1.2	1.6	32.0	386.0
1975	59.2	6.0	6.0	2.0	0.6	2.0	4.0	2.6	4.0	18.0	4.0	24.0
		30.0 ***							48.0 ***			
1976	2.0	2.0	0.4	0.2	0.0	0.8	0.4	2.4	2.0	20.0**	26.0	16.0
Average Without High Flows**	38.1	13.6	2.3	1.1	0.3	4.9	1.9	2.0	2.4		20.7	142.0
With High Flows		32.5 ***							17.1***	13.2***		
Angler[1]					Sunfishes							
1958	-	-	-	0.1	0.2	0.3	0.5	0.1	0.2		-	-
1959	-	-	-	1.9	0.7	0.5	0.5	0.4	0.2	0.5	-	-
1960	-	-	-	0.4	0.2	0.1	0.2	0.1	0.6	0.9	-	-
					Bluegill							
1974	*	*	0.4	-	-	-	-	-	-	-	-	7.5
1975	2.8	1.4	4.6	-	-	-	-	-	-	-	-	0.1
1976	*	0.1	0.2	-	-	-	-	-	-	-	-	0.1
Average	0.9	0.5	1.7	0.8	0.4	0.3	0.4	0.2	0.3	0.5	-	2.6
Peach Bottom Units No. 2 and 3												
1974[2]	1.8	13.8	1.0	6.0	0.3	0.0	0.0	0.0	2.0	2.0	16.0	136.0
1975	152.0	214.0	15.2	2.0	4.0	3.0	0.5	0.0	2.0	30.0	4.0	2.4
		632.0***							924.0***			
1976	0.0	0.0	1.4	0.0	0.0	0.2	0.2	2.2	2.6	294.0**	3.0	0.0
Average Without High Flows**	51.3	75.9	5.9	2.7	1.4	1.1	0.2	0.7	2.2		7.7	46.1
With High Flows		215.3***							309.5***	108.7***		
Angler[1]					Catfishes							
1958	-	-	-	1.8	0.6	1.3	1.9	1.6	1.7		-	-
1959	-	-	-	1.3	1.1	1.0	1.7	1.2	1.4	0.7	-	-
1960	-	-	-	0.9	5.6	9.7	0.9	1.3	4.0	6.8	-	-
					Channel catfish							
1974	*	0.0	0.3	-	-	-	-	-	-	-	-	0.0
1975	0.0	0.0	0.0	-	-	-	-	-	-	-	-	0.0
1976	0.0	*	*	-	-	-	-	-	-	-	-	0.0
Average	*	*	0.1	1.3	2.4	4.0	1.5	1.4	2.4	3.1	-	0.0
Peach Bottom Units No. 2 and 3												
1974[2]	280.0	260.2	57.5	68.4	25.0	22.0	26.0	18.0	44.0	12.0	32.0	246.0
1975	192.0	304.0	326.0	264.0	166.0	100.0	142.0	98.0	54.0	38.0	26.0	54.0
		4996.0***							430.0***			
1976	20.0	134.0	46.0	22.0	8.0	4.0	20.0	86.0	40.0	82.0***	26.0	90.0
Average Without High Flows**	164.0	232.7	143.2	118.1	66.3	42.0	62.7	67.3	46.0		28.0	130.0
With High Flows		1796.7***							171.3***	44.0***		

1 Data for years 1958, 1959 and 1960 was taken from Plosila (1961). Fishes caught were not listed by individual species, but were presented as catfishes, sunfishes and crappies.
2 Unit 2 only except Dec (Units 2 & 3 combined)
* Less than 0.1
** Data collected when river flow > 200,000 cfs not included.
*** Data collected when river flow > 200,000 cfs included

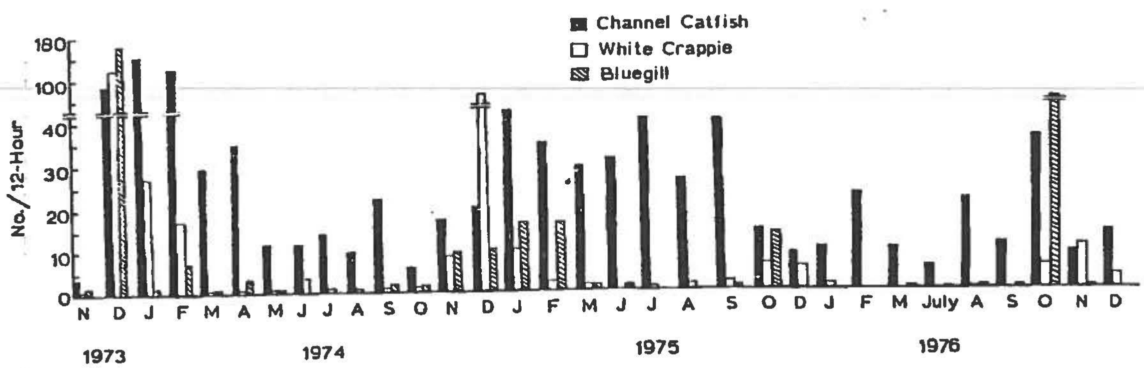

FIGURE 3.2-1

Monthly impingement (number per 12-hr) of the channel catfish, white crappie and bluegill at the screens for the Peach Bottom Station Unit No. 2, November 1973-December 1976.

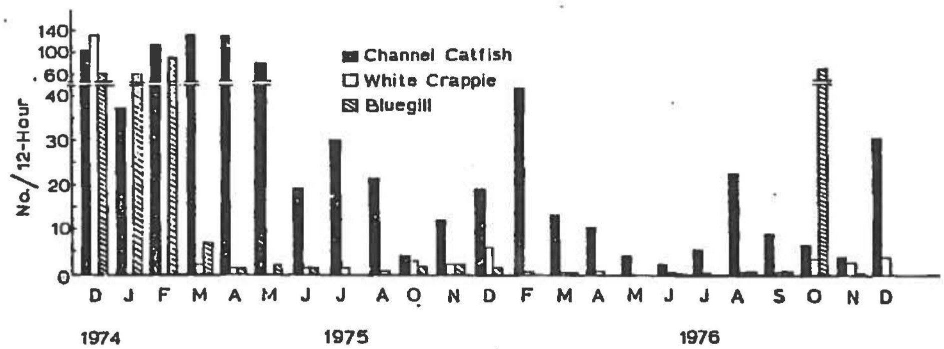

FIGURE 3.2-2

Monthly impingement (number per 12-hr) of the channel catfish, white crappie and bluegill at the screens for Peach Bottom Station Unit No. 3, December 1975-December 1976.

4.0 LITERATURE CITED

Anjard, C. A. 1976. Entrainment of fish eggs and larvae, p. 7-10 to 7-17. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Postoperational Report No. 5 on the Ecology of Conowingo Pond for the Period July 1975-December 1975. Ichthyological Associates, Inc. 501 p.

Bailey, R. M., J. E. Fitch, E. S. Herald, E. A. Lachner, C. C. Lindsey, C. R. Robins and W. B. Scott. 1970. A list of common and scientific Names of fishes from the United States and Canada (third edition). Amer. Fish. Soc. Spec. Publ. No. 6: 150 p.

Beeton, A. M. and J. M. Barker. 1974. Investigation of the influence of thermal discharge from a large electric power station on the biology and near-shore circulation of Lake Michigan - Part A: Biology. Special Report No. 18. Center for Great Lakes Studies, Milwaukee, Wisconsin.

Bodola, A. 1966. Life history of the gizzard shad, Dorosoma cepedianum (LeSuer), in Western Lake Erie. U. S. Fish. Wildl. Serv. Fish. Bull. 65(2):391-425.

Brooks, A. S., R. A. Smith and L. D. Jensen. 1974. Phytoplankton and primary productivity, p. 77-93. IN L. D. Jensen (ed.) Environmental responses to thermal discharges from the Indian River Station, Indian River, Delaware. Cooling Water Discharge Project (RP-49), Electric Power Research Institute. John Hopkins University, Baltimore.

Bush, R. A., E. B. Welch and B. W. Mar. 1974. Potential effects of thermal discharges on aquatic systems. Environ. Sci. Tech. 8(6):561-568.

Carlson, D. M. 1974. Responses of planktonic cladocerans to heated waters, p. 156-206. IN T. W. Gibbons and R. R. Sharitz (ed.) Thermal Ecology. 670 p.

Carpenter, E. J., B. B. Peck and S. J. Anderson. 1974. Survival of copepods passing through a nuclear power station on northeastern Long Island Sound, U.S.A. Marine Biology 24:49-55.

Davies, R. M. and L. D. Jensen. 1974. Entrainment of zooplankton at three mid-atlantic power plants, p. 131-155. IN L. D. Jensen (ed.) Proc. 2nd Entrainment and Intake Screening Workshop. Rept. No. 15, Edison Elec. Inst., Palo Alto, Calif. 347 p.

Earle, J. 1974. Zooplankton, p. 2-48 to 2-71. IN T. W. Robbins and D. Mathur, Preoperational Report on the Ecology of Conowingo Pond for Units No. 2 and 3. Ichthyological Associates, Inc., Drumore, Pennsylvania. xviii + 349 p.

Elier, H. O. and J. J. Delfino. 1974. Limnological and biologist studies of the effects of two modes of open-cycle nuclear power station discharge on the Mississippi River (1969-1973). Water Res. 8:995-1005.

Environmental Technical Specifications. 1973. Appendix B to Operating License for Peach Bottom Atomic Power Station Units No. 2 and 3, York County, Pennsylvania. Phila. Elec. Co. Docket Nos. 50-277 and 50-278. 53 p.

Euston, E. T. 1976. Winter Fishery, p. 4-73 to 4-79. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Postoperational Report No. 5 on the Cology of Conowingo Pond for the Period of July 1975-December 1975. Ichthyological Associates, Inc., Drumore, Pennsylvania. 501 p.

Euston, E. T., P. G. Heisey, D. Mathur, G. A. Nardacci, T. W. Robbins and T. F. Rosage. 1974. Biology of fishes, p. 4-75 to 4-79. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Preoperational Report on the Ecology of Conowingo Pond for Units No. 2 and 3. Ichthyological Associates, Inc., Drumore, Pennsylvania. xviii + 349 p.

Fox, J. L. and M. S. Moyer. 1973. Some effects of a power plant on marine microbiota. Chesapeake Sci. 14(1):1-10.

Glooschenko, W. A. and J. E. Moore. 1973. Surface distribution of chlorophyll a and primary production in Lake Huron, 1971. Tech. Rept. No. 406. Fish. Res. Bd. Canada.

Glooschenko, W. A., J. E. Moore and R. A. Vollenweider. 1974. Spatial and temporal distribution of chlorophyll a and phaeopigments in surface waters of Lake Erie. J. Fish. Res. Bd. Canada 31:265-274.

Hall, D. J. 1964. An experimental approach to the dynamics of a natural population of Daphnia galeata mendota. Ecology 45(1):94-111.

Heinle, D. R. 1969. Temperature and zooplankton. Chesapeake Sci. 10(3,4): 186-209.

Hocutt, C. H. 1973. Swimming performance of three warmwater fishes exposed to a rapid temperature change. Chesapeake Sci. 14(1):11-16.

Houston Lighting and Power Co. 1974. Environmental Report, South Texas Project Units 1 & 2. Docket STN 50-498.

Howell, G. P. 1969. Hudson River at Indian Point, Annual Report 4/16/68 to 4/15.69. Inst. Envir. Med., New York Univ. Med. Ctr., New York.

Hutchinson, G. E. 1967. A treatise on limnology, Vol. II. Introduction to lake biology and the limnoplankton. Wiley and Sons, N.Y. 1115 p.

Ichthyological Associates. 1977a. Limnology of Conowingo Pond, p. 2-1 to 2-33. IN Peach Bottom Atomic Power Station Postoperational Report No. 7 on the Ecology of Conowingo Pond for Units No. 2 and 3. Ichthyological Associates, Inc., Drumore, Pennsylvania.

Ichthyological Associates. 1977b. Entrainment of Zooplankton, p. 7-1 to 7-9. IN Peach Bottom Atomic Power Station Postoperational Report No. 7 on the Ecology of Conowingo Pond for the Period of July 1976-December 1976. Ichthyological Associates, Inc., Drumore, Pennsylvania.

Jester, D. B. 1972. Life history, ecology and management of the river carpsucker, Carpiodes carpio (Rafinesque), with reference to Elephant Butte Lake. Ag. Exp. Sta. Res. Rept. 243, New Mexico State Univ., Las Cruces. 120 p.

King, L. R. 1969. Swimming speed of the channel catfish, white crappie and other warmwater fishes from Conowingo Reservoir, Susquehanna River, Pa. Ichthyological Associates, Inc., Bull. No. 4. 74 p.

Lanner, M. and B. Pejler. 1973. The effect of cooling water discharges on zooplankton in a bay of Lake Malaren. Inst. Freshwater Res. Drottningholm Rept. No. 53, p. 31-33.

Lauer, G. J., W. T. Waller, D. W. Bath, W. Meeks, D. Heffner, T. Ginn, L. Zubarik, P. Kibko and P. C. Storm. 1974. Entrainment studies on Hudson River organisms, p. 37-82. IN L. D. Jensen (ed.), Proc. 2nd Entrainment and Intake Screening Workshop Rept. No. 15. Edison Elect. Inst., Palo Alto, Calif. 347 p.

Marcy, B. C., Jr. 1975. Entrainment of organisms at power plants, with emphasis on fishes--An overview. IN S. B. Saila. Fisheries and energy production. D. C. Heath and Co., Lexington, Massachusetts, U.S.A.

McFadden. J. T. 1976. Environmental impact assessment for fish populations, p. 89-137. IN R. K. Sharma, J. D. Buffington and J. T. McFadden (eds.) Proc. NRC Workshop on the Biological Significance of Environmental Impacts. NTIS, Springfield, Virginia.

McLaren, I. A. 1966. Predicting development rate of copepod eggs. Biol. Bull. 131:457-469.

McManus, W. J. 1975. Entrainment of Zooplankton, p. 7-1 to 7-7. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Postoperational Report No. 3 on the Ecology of Conowingo Pond for the Period of July 1974-December 1974. Ichthyological Associates, Inc., Drumore, Pennsylvania. xxiv + 350 p.

McManus, W. J. 1976. Entrainment of Zooplankton, p. 7-1 to 7-9. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Postoperational Report No. 5 on the Ecology of Conowingo Pond for the Period of July 1975-December 1975. Ichthyological Associates, Inc., Drumore, Pennsylvania. xxxiii + 501 p.

McNaught, D. C. (no date). Testimony for the AEC operating permit of the Commonwealth Edison Zion Nuclear Electric Generating Station. 21 p.

Patrick, R. 1969. Some effects of temperature on freshwater algae, p. 161-185. IN P. A. Krenkel and F. C. Parker (eds.), Biological aspects of thermal pollution. Vanderbilt Univ. Press.

Philadelphia Electric Company. 1975. Peach Bottom Atomic Power Station, Materials prepared for the Environmental Protection Agency 316(a) demonstration for PBAPS Units No. 2 and 3 on Conowingo Pond. Philadelphia Electric Co., Phila., Pennsylvania.

Plosila, D. S. 1961. Lower Susquehanna River sport fishery survey, p. 55-78. IN R. R. Whitney, The Susquehanna Fishery Study, 1957-1960. Md. Dept. Res. Ed. Contrib. No. 169.

Potomac Electric Power Co. 1973. Environmental Report, Construction Permit Stage, Douglas Point Nuclear Generating Station Units 1 & 2. Docket 50-448. 572 p.

Pratt, D. M. 1943. Analysis of population development in Daphnia at different temperatures. Biol. Bull. 85:116-140.

Raney, E. C. 1973. Reasons for the expected environmental improvement in Conowingo Pond in relation to recreational activities of man, p. 6-1 to 6-13. IN T. W. Robbins and D. Mathur, Peach Bottom Atomic Power Station Preoperational Report on the Cology of Conowingo Pond for Units No. 2 and 3. Ichthyological Associates, Inc., Drumore, Pennsylvania. xviii + 349 p.

Richards, F. A. and T. G. Thompson. 1952. The estimation and characterization of plankton populations by pigment analysis. II. A spectrophotometric method for the stimation of plankton pigments. J. Mar. Res. 11:156-172.

Robbins, T. W. and D. Mathur. 1974. Peach Bottom Atomic Power Station Preoperational Report on the Ecology of Conowingo Pond for Units No. 2 and 3. Ichthyological Associates, Inc., Drumore, Pennsylvania. xviii + 349 p.

Robbins, T. W. and D. Mathur. 1975. Peach Bottom Atomic Power Station Postoperational Report No. 4 on the Ecology of Conowingo Pond for the Period January 1975-June 1975. Ichthyological Associates, Inc., Drumore, Pennsylvania. xxiii + 322 p.

Robbins, T. W. and D. Mathur. 1976a. Peach Bottom Atomic Power Station Postoperational Report No. 5 on the Ecology of Conowingo Pond for the Period July 1975-December 1975. Ichthyological Associates, Inc., Drumore, Pennsylvania. xxxiii + 501 p.

Robbins, T. W. and D. Mathur. 1976b. Peach Bottom Atomic Power Station Supplementary Materials Prepared for the Environmental Protection Agency 316(a) Demonstration for PBAPS Units No. 2 and 3 on Conowingo Pond. 251 p.

Schindler, D. W. 1969. Two useful devices for vertical plankton and water sampling. J. Fish. Res. Bd. Canada 26(7):1948-1955.

Strickland, J. D. H. and T. R. Parsons. 1972. A practical handbook of seawater analysis. Bulletin 167. 2nd edition. Fish. Res. Bd. Canada.

Verduin, J. (no date). Testimony for the AEC operating permit of the Commonwealth Edison Zion Nuclear Electric Generating Station. Southern Illinois University, Carbondale, Illinois.

Whitney, R. R. 1961. The Susqeuhanna Fishery Study, 1957-1960. Md. Dept. Res. Ed. Contrib. No. 169.

APPENDIX A

ENTRAINMENT OF FISH EGGS AND LARVAE: 1973

Methods

Sampling stations were established at the intake (immediately before the inner set of vertical traveling screens of Unit 2), discharge (at the bridge between the discharge pond and the discharge canal) and in the discharge canal. Sampling was regulated by the Peach Bottom start-up testing schedule.

Samples of 15 min duration were taken at the surface and bottom at each station simultaneously using 1 m plankton nets, held by anchored bouys or attached by lines to the shore. A General Oceanics Model 2030 flowmeter was mounted in the mouth of each net to determine the volume of water strained. The intake and discharge were sampled once a week in daylight hours from 19 June to 7 August 1973. The circulating water pumps were operated at the request of Ichthyological Associates. The discharge canal was sampled only on 7 August because the cooling towers were not operational prior to this date. Sampling was terminated on 7 August because the densities of larvae were too low to estimate mortality.

Specimens that showed some reaction to 10% formalin were considered alive while those not displaying any movement were considered dead.

Results

Densities of larvae in each sample were extremely low (Table 7.2-1) and precluded estimation of mortality due to mechanical damage. The combined average density of fish larvae at the three stations was 9.3 larvae per 1000 m^3. As in the case of zooplankton, the number of dead fish larvae

in the samples taken at the intake generally exceeded those from the discharge. The most commonly entrained fishes were larvae of the carp, quillback and *Lepomis* spp. (bluegill and pumpkinseed less than 14 mm fork length). No eggs were collected.

TABLE 7.2-1

Densities of live and dead larval fishes (25 mm or less in size) per 1000 m^3 at the surface and bottom at the intake, discharge and discharge canal of Peach Bottom Atomic Power Station between 19 June and 7 August 1973.

Station	Intake				Discharge				Discharge Canal						
Depth	Surface		Bottom		Surface		Bottom		Surface		Bottom		Average	Average	
No. Samples	21		21		24		26		3		3		Density	Density	Average
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Density
Species															
C. carpio	0.42	2.09	0.99	0.99	7.40	0.78	7.47	0.28	-	-	-	-	3.97	0.87	4.85
N. spilopterus	-	0.42	-	-	0.39	-	-	-	-	-	-	-	0.08	0.08	0.16
C. cyprinus	-	-	0.66	0.99	2.34	-	3.04	0.55	-	-	-	-	1.51	0.40	1.91
I. punctatus	-	-	1.97	-	-	-	0.83	-	-	-	-	-	0.72	-	0.72
Centrarchidae	-	-	-	-	-	-	0.28	-	-	-	-	-	0.08	-	0.08
L. macrochirus	-	-	-	-	-	-	-	-	-	2.22	-	1.93	-	0.16	0.16
P. annularis	-	-	-	-	-	-	0.28	-	-	-	-	-	0.08	-	0.08
Lepomis spp.	0.42	0.84	-	-	1.17	-	0.83	0.55	-	2.22	-	-	0.56	0.40	0.95
E. olmstedi	-	-	0.33	-	-	-	0.55	-	-	-	1.93	-	0.32	-	0.32
Unidentifiable	-	-	-	-	0.39	-	-	-	-	-	-	-	0.08	-	0.08
Totals	0.84	3.34	3.94	1.97	11.69	0.78	13.28	1.38	0.00	4.44	1.93	1.93	7.39	1.91	9.30

APPENDIX B

ENTRAINMENT OF FISH EGGS AND LARVAE: 1974

Methods

Studies to determine the mortality of fish larvae entrained in the cooling water system of the Peach Bottom Atomic Power Station Unit No. 2 began in May 1974. Prior to 17 June, samples were taken when Unit No. 2 was operated at varying power levels (34-98%). After 17 June, Unit No. 2 operated at 98-100% power during all but one sampling period (26 July; 70-76%). Temporary plant shutdowns and other problems related to station operation occasionally interrupted or prevented scheduled sampling.

Samples were taken simultaneously in the Unit No. 2 intake pond and in the discharge canal (approximately 250 yards downstream from cooling tower C). A total of four surface and four bottom collections was taken from each location both in the day and at night. Samples were taken twice weekly from 10 May until 21 June and once a week thereafter until 2 August. On 10 and 17 May, collections were taken in the intake pond in daytime only.

Larvae were collected using plankton nets of 1 m diameter and 0.5-mm mesh size. Nets were hung from a cable stretched across the Unit No. 2 intake pond. In the discharge canal, nets were suspended from anchored buoys. The nets were set for 10 minutes, retrieved and the sample emptied into individual, aerated, styrofoam containers. Live and dead larvae were separated on site. Specimens that showed some reaction to 10% formalin were considered alive while those not displaying movement were considered dead. The time lag from collection to sorting of larvae was usually less than one-hald hour and never more

than one hour. Specimens were preserved in 10% formalin and later transferred to 40% isopropanol, identified and measured.

The volume of water filtered in each sample was determined from a General Oceanics Model 2030 flow meter mounted in the mouth of each net. In 15% of the collections, the meters became clogged with debris and exact volume could not be determined. In these cases the sample volume was estimated. If only one daily sample was affected, the volume was estimated using the average sample volume for the day. If more than one sample was affected, the average volume for the entire season was used. Because of the low overall density of larvae, the data from all collections on a given date from each location were pooled. Densities were expressed as the number of larvae per 1000 m^3.

Mortalities were calculated from the densities of live and dead larvae at the intake and discharge. Adjustments for settling or disintegration of dead larvae in the cooling ponds and discharge canal were made by adding the difference in densities between the intake and the discharge to the densities of the dead larvae at the discharge. The proportion dead at the intake was then subtracted from the adjusted proportion dead at the discharge to estimate the mortality due to entrainment.

The minimum number of larvae needed to detect a real difference between mortalities at the intake and discharge was calculated using the formula (Sokal and Rohlf, 1969, p. 609):

$$N = \frac{C}{(\text{arcsine } P_1 - \text{arcsine } P_2)^2}$$

where C = 17, 249 for 90% certainly, $P < .05$; P_1 = proportion dead at intake; P_2 = adjusted proportion dead at discharge. Estimates of entrainment

mortality were possible only on days where the number of larvae taken in the intake pond equalled or exceeded N.

Mortalities were calculated for the larvae of carp, quillback, channel catfish and tessellated darter. The densities of the remaining species were too low to adequately determine mortality.

Densities of fish larvae immediately offshore of the Station cooling water intakes were established using the data from Transect Station 562. This station was sampled weekly throughout the spawning season as part of the monitoring program in the Pond. However, the samples were not collected at the same time as the entrainment samples and the data provided for qualitative comparisons only.

Results

The most commonly entrained larval fishes were the carp, quillback, channel catfish and tessellated darter (Table 7.2-1). The same species were common off the intake. Larvae of the gizzard shad, spotfin shiner, white sucker, rock bass, white crappie, Lepomis sp. (bluegill and pumpkinseed less than 14 mm), logperch and shield darter were also entrained. No eggs were taken in the intake and discharge canal although a single carp egg was taken in the Pond off the intake. No larvae of the game fishes such as the walleye, smallmouth bass and largemouth bass were entrained.

Entrainment mortalities, excluding those where N was not exceeded and negative mortalities, ranged from 52-100% (Tables 7.2-2 to 7.2-5). The mortalities did not differ substantially between species. When few larvae were collected at the intake real differences in mortality would not be statistically detected. Negative estimates were confined primarily to the channel catfish and tessellated darter and were related to the vertical

distribution and relative size of larvae. The average size (Table 7.2-6) of larvae of these species (14-21 mm) was greater than that of the carp and quillback larvae (7-9 mm). Also, the carp and quillback larvae were distributed more evenly throughout the water column (Table 7.2-7) than the channel catfish and tessellated darter which were taken mostly in bottom collections.

The demersal distribution of the channel catfish and tessellated darter larvae required that the samples be taken close to the bottom to obtain reliable density estimates. The discharge station nets were one to two feet closer to the bottom than those in the intake. This difference in location of nets may have reduced the sampling efficiency of the intake nets for channel catfish and tessellated darter larvae and resulted in negative mortality estimates.

Negative mortalities may have also resulted from the large size of the channel catfish and tessellated darter larvae. Noble (1971), indicated for the walleye and yellow perch that although net avoidance capability differed between species, it began at less than 10 mm and increased with increasing size. Thus, the avoidance capability of the channel catfish and tessellated darter larvae was probably considerably greater than that of the carp and quillback, based on their respective sizes. This potential for net avoidance may have been significantly reduced by the stress imposed on the larvae while being transported through the condenser system. Any significant reduction in avoidance capability between the intake and discharge locations would have increased the sampling efficiency of the discharge nets and resulted in negative mortality estimates.

TABLE 7.2-1

Mean densities (number per 1000 m^3) of fish larvae ($\leq$ 25 mm) collected in the Peach Bottom Atomic Power Station Unit No. 2 intake pond, discharge canal, and at transect Station 562, 9 May - 7 August 1974.

Location No. Samples	Intake 197	Discharge 184	Station 562 48
Species			
D. cepedianum	-	0.04	-
Cyprinidae	0.16	0.07	1.14
C. carpio	6.29	1.43	8.41
N. procne	-	-	0.15
N. rubellus	-	-	0.23
N. spilopterus	0.16	-	-
C. cyprinus	5.48	2.13	11.98
C. commersoni	0.41	0.07	0.99
I. punctatus	2.70	3.71	12.51
L. auritus	0.08	-	0.08
L. macrochirus	-	-	0.08
M. dolomieui	-	-	0.23
P. annularis	0.08	0.04	0.15
Lepomis sp.	0.74	0.55	0.45
E. olmstedi	15.20	25.88	138.85
P. caprodes	0.08	-	-
P. peltata	0.65	0.33	1.14
Unidentifiable	-	-	0.45

TABLE 7.2-2

Daily estimated mortality of larval carp, *Cyprinus carpio*, (25 mm or less in size) due to entrainment at Peach Bottom Atomic Power Station Unit No. 2, May through August, 1974. All densities expressed as number per 1000 m^3.

Date	10 May[1]	17 May[1]	20 May	24 May	10 Jun[2]	14 Jun	17 Jun	21 Jun	28 Jun	1 Jul	12 Jul	19 Jul	26 Jul	2 Aug	Weighted Average[3]
Intake															
Surface Water Temp (F)	57.7	66.5	69.3	70.3-71.0	76.0	76.0	73.0	76.0	69.5-71.5	73.0	78.0-80.0	78.0-80.5	77.5-78.0	78.0-79.0	
No. Collected	0	0	0	3	18	26	15	5	5	3	0	2	0	0	
Density Live	0.0	0.0	0.0	3.30	31.83	32.43	10.50	3.41	3.94	3.40	0.0	2.53	0.0	0.0	5.70
Density Dead	0.0	0.0	0.0	0.0	15.92	2.70	7.00	2.27	0.99	0.0	0.0	0.0	0.0	0.0	1.61
% Dead	-	-	-	0.00	33.34	7.68	40.00	39.96	12.48	0.00	-	0.00	-	-	22.02
Discharge															
Surface Water Temp (F)	65.7	-	71.0	77.9	81.0	78.0	82.0	83.0	75.5-76.0	79.5-81.8	82.0-84.0	87.0-88.0	82.0-84.0	86.0-87.0	
No. Collected	-	-	3	3	14	12	1	1	3	1	1	0	0	0	
Density Live	-	-	0.34	0.60	6.71	2.66	0.0	0.0	0.91	0.46	0.0	0.0	0.0	0.0	0.66
Density Dead	-	-	0.67	0.40	6.71	3.73	0.44	0.32	0.46	0.0	0.30	0.0	0.0	0.0	0.77
% Dead	-	-	66.33	30.53	50.00	58.37	100.00	100.00	33.57	0.00	100.00	-	-	-	53.84
Adjusted % Dead	-	-	-	72.42	85.94	92.43	100.00	100.00	81.54	86.47	-	100.00	-	-	90.97
% Entrainment Mortality	-	-	-	72.42	52.60	84.75	60.00	60.04	69.05	86.47	-	100.00	-	-	68.95
N				5	16	5	7	7	9	4		2			

1 = Samples taken in the intake canal during daylight only
2 = No night samples taken due to Peach Bottom Atomic Power Station shutdown
3 = Data from 10 and 17 May not included
N - Number of larvae needed at intake to detect a real difference in mortality at intake and discharge

TABLE 7.2-3

Daily estimated mortality of larval quillback, <u>Carpiodes cyprinus</u>, (25 mm or less in size) due to entrainment at Peach Bottom Atomic Power Station Unit No. 2 May through August 1974. All densities expressed as number per 1000 m^3.

Date	10 May[1]	17 May[1]	20 May	24 May	10 Jun[2]	14 Jun	17 Jun	21 Jun	28 Jun	1 Jul	12 Jul	19 Jul	26 Jul	2 Aug	Weighted Average[3]
Intake															
Surface Water Temp (F)	57.7	66.5	69.3	70.5-71.0	76.0	76.0	75.0	76.0	69.5-71.5	73.0	78.0-80.0	78.0-80.5	77.5-78.0	78.0-79.0	
No. Collected	0	33	12	14	0	4	1	0	2	1	0	0	0	0	
Density Live	0.0	22.61	5.60	13.22	0.0	2.70	0.0	0.0	1.97	1.13	0.0	0.0	0.0	0.0	2.28
Density Dead	0.0	18.84	4.00	2.20	0.0	2.70	1.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.95
% Dead	-	45.44	41.67	14.26	-	50.00	100.00	-	0.00	0.00	-	-	-	-	22.41
Discharge															
Surface Water Temp (F)	65.7	-	71.0	77.9	81.0	78.0	82.0	83.0	75.5-76.0	79.5-81.8	82.0-84.0	87.0-88.0	82.0-84.0	86.0-87.0	
No. Collected	-	-	26	16	1	3	11	1	4	0	0	0	0	0	
Density Live	-	-	5.06	3.62	0.96	1.60	4.43	0.52	ď.46	0.0	0.0	0.0	0.0	0.0	1.63
Density Dead	-	-	3.71	2.82	0.0	0.0	0.44	0.0	-1.37	0.0	0.0	0.0	0.0	0.0	0.70
% Dead	-	-	42.30	43.78	0.00	0.00	9.03	0.00	75.27	-	-	-	-	-	32.86
Adjusted % Dead	-	-	47.29	76.52	-	70.42	-278.63	-	77.16	100.00	-	-	-	-	55.72
% Entrainment Mortality	-	-	5.62	62.26	-	20.42*	-178.63	-	77.16	100.00	-	-	-	-	33.31
N			44	12		119			5	2					

1 = Samples taken in the intake canal during daylight only
2 = No night samples taken due to Peach Bottom Atomic Power Station shutdown
3 = Data from 10 and 17 May not included
N = Number of larvae needed at intake to detect a real difference in mortality at intake and discharge

TABLE 7.2-4

Daily estimated mortality of larval channel catfish, *Ictalurus punctatus*, (25 mm or less in size) due to entrainment at Peach Bottom Atomic Power Station Unit No. 2, May through August 1974. All densities expressed as number per 1000 m^3.

Date	10 May[1]	17 May[1]	20 May	24 May	10 Jun[2]	14 Jun	17 Jun	21 Jun	28 Jun	1 Jul	12 Jul	19 Jul	26 Jul	2 Aug	Weighted Average[3]
Intake															
Surface Water Temp (F)	57.7	66.5	69.3	70.5-71.0	76.0	76.0	75.0	76.0	69.5-71.5	73.0	78.0-80.0	78.0-80.5	77.5-78.0	78.0-79.0	
No. Collected	0	0	0	0	0	0	2	1	4	21	2	1	1	1	
Density Live	0.0	0.0	0.0	0.0	0.0	0.0	2.33	1.14	3.94	23.78	0.96	1.26	1.10	1.15	2.94
Density Dead	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.96	0.0	0.0	0.0	0.09
% Dead	-	-	-	-	-	-	0.00	0.0	0.00	0.00	50.00	0.00	0.00	0.00	2.87
Discharge															
Surface Water Temp (F)	63.7	-	71.0	77.9	81.0	78.0	82.0	83.0	75.5-76.0	79.5-81.8	82.0-84.0	87.0-88.0	82.0-84.0	86.0-87.0	
No. Collected	-	-	0	0	0	0	25	19	19	18	10	6	0	4	
Density Live	-	-	0.0	0.0	0.0	0.0	10.18	8.85	8.19	5.96	2.95	2.29	0.0	1.28	3.31
Density Dead	-	-	0.0	0.0	0.0	0.0	0.89	1.04	0.46	2.29	0.0	0.0	0.0	0.43	0.30
% Dead	-	-	-	-	-	-	8.04	10.52	5.32	27.76	0.00	0.00	-	25.29	10.78
Adjusted % Dead	-	-	-	-	-	-	-336.91	-673.32	-107.87	74.94	-53.65	-81.75	100.00	-11.30	-5.75
% Entrainment Mortality	-	-	-	-	-	-	-336.91	-673.32	-107.87	74.94	-3.65	-81.75	100.00	-11.30	-8.62
N										5			2		

1 = Samples taken in the intake canal during daylight only
2 = No night samples taken due to Peach Bottom Atomic Power Station shutdown
3 = Data from 10 and 17 May not included
N = Number of larvae needed at intake to detect a real difference in mortality at intake and discharge

TABLE 7.2-5

Daily estimated mortality of larval tessellated darter, Etheostoma olmstedi, (25 mm or less in size) due to entrainment at Peach Bottom Atomic Power Station Unit No. 2, May through August 1974. Densities expressed as number per 1000 m^3.

Date	10 May[1]	17 May[1]	20 May	24 May	10 Jun[2]	14 Jun	17 Jun	21 Jun	28 Jun	1 Jul	12 Jul	19 Jul	26 Jul	2 Aug	Weighted Average[3]
Intake															
Surface Water Temp (F)	57.7	66.5	69.3	70.5-71.0	76.0	76.0	73.0	76.0	69.5-71.5	73.0	78.0-80.0	78.0-80.5	77.5-78.0	78.0-79.0	
No. Collected	0	5	29	2	1	24	59	27	28	10	0	1	1	1	
Density Live	0.0	3.76	16.80	2.20	2.65	32.43	60.68	26.14	24.63	11.33	0.0	1.26	1.10	1.15	15.39
Density Dead	0.0	2.51	6.40	0.0	0.0	0.0	5.83	4.55	2.96	0.0	0.0	0.0	0.0	0.0	1.80
% Dead	-	40.03	27.59	0.00	0.00	0.00	8.77	14.83	10.73	0.00	-	0.00	0.00	0.00	10.47
Discharge															
Surface Water Temp (F)	65.7	-	71.0	77.9	81.0	78.0	82.0	83.0	75.5-76.0	79.5-81.8	82.0-84.0	87.0-88.0	82.0-84.0	86.0-87.0	
No. Collected	-	-	26	24	0	24	30	224	243	80	6	1	3	1	
Density Live	-	-	4.05	7.24	0.0	12.24	11.95	106.19	100.59	33.00	1.77	0.38	1.57	0.43	21.61
Density Dead	-	-	18.90	2.41	0.0	0.53	1.33	10.41	10.01	3.67	0.0	0.0	0.0	0.0	4.26
% Dead	-	-	82.35	24.97	0.00	4.15	10.02	8.93	9.05	10.01	0.00	0.00	0.00	0.00	16.46
Adjusted % Dead	-	-	82.54	-229.09	100.00	62.26	82.03	-246.01	-264.39	-191.26	-	69.84	-42.73	62.61	-25.77
% Entrainment Mortality	-	-	54.95	-229.09	100.00	62.26	73.26	-231.18	-286.63	-191.26	-	69.84	-42.73	62.61	-36.24
N			15		2	6	8					5		6	

1 = Samples taken in the intake canal during daylight only
2 = No night samples taken due to Peach Bottom Atomic Power Station shutdown
3 = Data from 10 and 17 May not included
N = Number of larvae needed at intake to detect a real difference in mortality at intake and discharge

TABLE 7.2-6

Mean fork length and range (mm) of the common larval fishes ($\leq$ 25 mm) collected in the Peach Bottom Atomic Power Station Unit No. 2 intake pond, discharge canal and at transect Station 562, May-August 1974.

	Station 562	Intake	Discharge
Species			
C. carpio	7.7 (5-23)	7.7 (5-16)	7.3 (4-21)
C. cyprinus	7.6 (6-9)	8.3 (7-14)	7.6 (5-10)
I. punctatus	20.3 (14-25)	14.6 (13-21)	14.9 (13-22)
E. olmstedi	19.4 (5-25)	18.7 (5-25)	19.7 (4-25)

TABLE 7.2-7

Mean densities per $10^3 m^3$ of larval fishes ($\leq$ 25 mm) taken at the surface and bottom in the intake and discharge of Peach Bottom Atomic Power Station Unit No. 2; and Transect Station 562, 20 May - 9 August 1974.

Station	Station 562		Intake		Discharge	
Depth	Surface	Bottom	Surface	Bottom	Surface	Bottom
Volume M^3	5,535	5,453	5,191	5,338	14,062	13,142
Species						
C. carpio	9.94	20.27	8.48	6.18	1.35	1.52
C. cyprinus	8.31	4.77	1.54	4.87	1.99	2.28
I. punctatus	2.89	27.33	1.73	4.50	2.84	4.64
E. olmstedi	2.89	318.37	5.78	28.29	9.24	36.07

LITERATURE CITED

Noble, R. L. 1971. An evaluation of the meter net for sampling fry of the yellow perch, *Perca flavescens*, and walleye, *Stizostedion v. vitreum*. Chesapeake Sci. 12:47-48.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman Co., San Francisco. 776 p.

Intake Screen Velocity Survey for Peach Bottom Atomic Power Station Unit 2

by
Arthur S. Hunnewell
and
Edward C. Brainard, II

Prepared for
Philadelphia Electric Company

May, 1974

Environmental Devices Corp.
Environmental Survey Division
Marion, Massachusetts 02738

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1. ABSTRACT

Two current surveys were made of the flows at the rotating trash screens for Peach Bottom Atomic Power Station Unit 2 on January 25 and April 1, 1974 with Unit 2 circulation pumps running. With an average Pond elevation of 106.48 feet the maximum observed flow was 0.79 ft/sec with an average flow of 0.60 ft/sec for all twelve screens. Strongest flows were observed at the southern screens with lower velocities at the northern screens.

2. INTRODUCTION

On January 25 and April 1, 1974, ENDECO conducted a comprehensive field survey of the current flow distribution for the rotating trash screens of Peach Bottom Atomic Power Station Unit 2 at Peach Bottom, Pennsylvania. The purpose of the study was to comply with sections 6.1.b and 7.4.2 of the "Appendix A to Operating License DTR-44 Technical Specifications and Bases for the Full Power Full Term Peach Bottom Atomic Power Station Units Number 2 and 3 Philadelphia Electric Company Docket Numbers 50-277 50-278" which require that a single survey be made of flow velocities through each of the twelve rotating trash screens of Unit 2 with all three of the Unit's circulation pumps running.

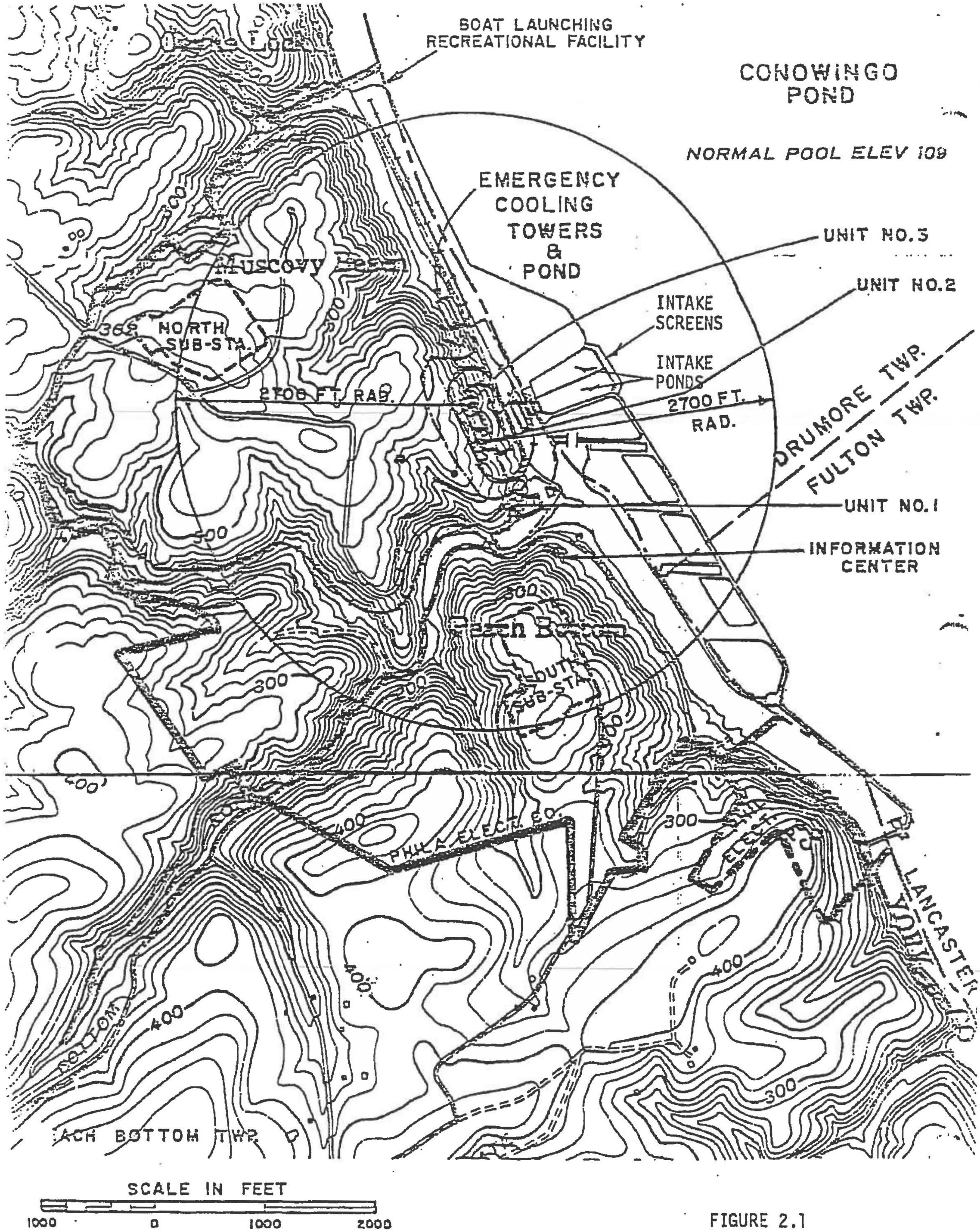
The survey was conducted from a small boat located in the Unit 2 intake pond which is behind the trash screen building. A Type 110 Remote Reading Current Meter was employed to record velocity. The instrument probe was lowered from the small boat which was anchored in each of the separate channels located behind each of the twelve screens. Readings were taken at the surface to fifteen feet* at five foot intervals and the observations were read in knots (1 knot = 1.6889 ft/sec).

Although all three circulation pumps were supposed to be on

* Although the bottom profile showed a depth range of 20 to 23 feet behind the screens, to protect the instrument probe, the last reading was always taken five feet above the bottom. Depth soundings were taken with a lead line.

during the study, only two were operating during the survey made for Unit 2 on January 25. However this data has been treated as an exploratory preliminary study and the information has been used only to compare patterns of velocity distribution.

Figure 2.1 shows the relative location of the screens to PBAPS.



BOAT LAUNCHING
RECREATIONAL FACILITY
CONOWINGO
POND
NORMAL POOL ELEV 109
EMERGENCY
COOLING
TOWERS
&
POND
UNIT NO.3
UNIT NO.2
INTAKE
SCREENS
INTAKE
PONDS
2700 FT.
RAD.
2700 FT. RAD.
DRUMORE TWP.
FULTON TWP.
UNIT NO.1
INFORMATION
CENTER
NORTH
SUB-STA.
Muscovy
SOUTH
SUB-STA.
PHILA ELECT. CO.
LANCASTER CO.
YORK CO.
300
400
500
SCALE IN FEET
1000
0
1000
2000

FIGURE 2.1

3. METHODOLOGY

a. Equipment

Although in the original program outline, it was stated that the current flow study would be conducted along the front of the rotating screens, the design of the screen building restricted access to the front area. Each of the twelve rotating screens has its own channel separated from the others and each rectangular channel cross-section is the same (12.5 feet wide x 24.5 feet deep at a Pond elevation of 108.5) both in front and back of the screen. The only exception is the southern-most rotating trash screen which has a more restricted cross-section in front of the screen. In front of each of the screens, except for the southern-most one, there has been constructed a flow regulating wall (18 inches high x 24 inches wide) on the bottom and built out and away from the screens. Whether this varies the velocities is hard to evaluate since silting, which has occurred on both sides of the screen, appears to have buried the wall. In light of the fact that there was access by boat directly behind each of the screens, and because the channel cross-section was similar on both sides, excpet for the southern-most screen, it was concluded that a satisfactory study with accurate results could be conducted from behind the trash screens.

An ENDECO Type 110 Remote Reading Current Meter (see Appendix A) was used from the small boat to obtain the fine grain data for the survey. The instrument was lowered over the side of the boat with a 20 pound weight suspended underneath it to depress the unit and to

maintain the lowering line vertical. The base of the weight was about five feet below the horizontal center axis of the instrument. Readings were taken at five foot intervals from the surface to fifteen feet and were read from the Type 110 Deck Readout. The rotor calibrations are traceable to calibrations made in the one meter square cross-section continuous flow channel at the Chesapeake Bay Institute of Johns Hopkins University. The compass was swung at ENDECO using the local Magnetic North as a reference, and a compass deviation curve, based upon 15-degree interval readings, was developed for the instrument for correction of current direction data.

b. Fine Grain Current Survey

On January 25 with two circulation pumps running and April 1, 1974 with three circulation pumps running, a fine grain survey was made from a 16 foot boat inside the channel for each of the twelve rotating screens. The boat was anchored diagonally across the width of the channel, because its length exceeded the width of the channel. After the boat was anchored, the portable current meter was lowered over the upstream side of the boat at the center axis position of the channel. Velocity and direction were tabulated at each 5 foot depth interval. The elapsed time for each screen study, including set up and observation, was about ten minutes. Total time to complete the entire survey was about two hours.

Tables 3.b.1 and 3.b.2 provide a summary of the information gathered on both dates.

The screens were numbered 1 to 12, south to north, for easy reference.

Table 3.b.1

INTAKE SCREEN VELOCITIES - UNIT 2
January 25, 1974
(1030 - 1145 Hours E.S.T.)

(VELOCITY IN KNOTS)

TIME:	Screen	Depth 0	5	10	15	Ave
1030	1	0.30	0.40	0.40	0.35	0.36
	2	0.25	0.25	0.15	0.30	0.24
	3	0.25	0.25	*	0.15	0.16
	4	0.25	0.20	0.10	0.15	0.18
	5	0.20	0.20	0.10	0.15	0.16
	6	0.25	0.25	0.15	0.15	0.20
	7	0.25	0.25	0.10	0.15	0.19
	8	0.20	0.25	0.15	0.15	0.19
	9	0.15	0.25	0.15	0.20	0.19
	10	0.15	0.20	0.20	0.15	0.18
	11	0.15	0.10	0.10	0.20	0.14
	12	0.15	0.15	0.15	0.15	0.15
1145	Stop					

Maximum: 0.40 Minimum: * Average: 0.19

(VELOCITY IN FT/SEC)

TIME:	Screen	Depth 0	5	10	15	Ave
1030	1	0.51	0.68	0.68	0.59	0.61
	2	0.42	0.42	0.25	0.51	0.40
	3	0.42	0.42	*	0.25	0.27
	4	0.42	0.34	0.17	0.25	0.30
	5	0.34	0.34	0.17	0.25	0.27
	6	0.42	0.42	0.25	0.25	0.34
	7	0.42	0.42	0.17	0.25	0.32
	8	0.34	0.42	0.25	0.25	0.32
	9	0.25	0.42	0.25	0.34	0.32
	10	0.25	0.34	0.34	0.25	0.30
	11	0.25	0.17	0.17	0.34	0.23
	12	0.25	0.25	0.25	0.25	0.25
1145	Stop					

Maximum: 0.68 Minimum: * Average: 0.33

1.00 Knot = 1.6889 Ft/Sec

* Velocity below instrument threshold .05 knots (.08 ft/sec)

Table 3.b.2

INTAKE SCREEN VELOCITIES - UNIT 2
April 1, 1974
(0945 - 1145 Hours E.S.T.)

(VELOCITY IN KNOTS)

TIME:	Screen	Depth 0	5	10	15	Ave
0945	1	0.41	0.45	0.47	0.47	0.45
1000	2	0.30	0.40	0.40	0.40	0.38
1010	3	0.37	0.43	0.40	0.40	0.40
1020	4	0.33	0.37	0.37	0.40	0.37
1030	5	0.35	0.30	0.30	0.37	0.33
1040	6	0.30	0.33	0.33	0.35	0.33
1050	7	0.37	0.35	0.37	0.35	0.36
1100	8	0.30	0.37	0.35	0.37	0.35
1110	9	0.33	0.33	0.35	0.33	0.34
1120	10	0.27	0.30	0.33	0.33	0.31
1130	11	0.33	0.30	0.33	0.30	0.32
1140	12	0.35	0.33	0.30	0.30	0.32
1145	Stop					

Maximum: 0.47 Minimum: 0.27 Average: 0.35

(VELOCITY IN FT/SEC)

TIME:	Screen	Depth 0	5	10	15	Ave
0945	1	0.69	0.76	0.79	0.79	0.76
	2	0.51	0.68	0.68	0.68	0.63
	3	0.63	0.73	0.68	0.68	0.68
	4	0.56	0.63	0.63	0.68	0.62
	5	0.59	0.51	0.51	0.63	0.56
	6	0.51	0.56	0.56	0.59	0.55
	7	0.63	0.59	0.63	0.59	0.61
	8	0.51	0.63	0.59	0.63	0.59
	9	0.56	0.56	0.59	0.56	0.57
	10	0.46	0.51	0.56	0.56	0.52
	11	0.56	0.51	0.56	0.51	0.53
	12	0.59	0.56	0.51	0.51	0.54
1145	Stop					

Maximum: 0.79 Minimum: 0.46 Average: 0.60

1.00 Knot = 1.6889 Ft/Sec

Table 3.b.3

POND ELEVATIONS

January 25, 1974 Time:	Elevation:	April 1, 1974 Time:	Elevation:
1030	108.48 ft	0930	106.08 ft
1100	108.46 ft	1000	106.26 ft
1130	108.44 ft	1030	106.40 ft
1200	108.43 ft	1100	106.56 ft
1230	108.41 ft	1130	106.72 ft
1300	108.41 ft	1200	106.85 ft

Average Elevation = 108.44
Natural River Flow = 116,100 cfs*

Average Elevation = 106.48
Natural River Flow = 89,900 cfs*

Screen	Depth**	Screen	Depth***
1	23.58 ft	1	22.18 ft
2	23.58 ft	2	22.09 ft
3	22.58 ft	3	20.54 ft
4	23.42 ft	4	21.00 ft
5	23.42 ft	5	20.95 ft
6	23.75 ft	6	22.07 ft
7	23.58 ft	7	22.51 ft
8	23.58 ft	8+	23.04 ft
9	23.33 ft	9	22.49 ft
10	23.50 ft	10	21.68 ft
11	23.58 ft	11	21.88 ft
12	23.33 ft	12	22.17 ft

* 24 Hour Average
** Reference Pond elevation is 108.41 ft for January 25.
*** Reference Pond elevation is 106.85 ft for April 1.

Deviation of depth readings between January 25 and April 1 when using 108.41 ft as the reference elevation averages $\pm$0.46 ft ($\pm$5.6 in). Maximum variation was 1.02 ft (12.24 in). Reading variation is due to bottom penetration by the weight of the measuring line and irregular bottom topography due to silting.

All Pond elevation readings were taken from Conowingo Hydro Log.

POND ELEVATIONS

(Continued)

+ Expected depth with no silting for January 25 was 24.41 ft at a Pond elevation of 108.41 ft.

Expected depth with no silting for April 1 was 22.85 ft at a Pond elevation of 106.85 ft.

However at Screen 8 on April 1 the depth behind the screen exceeded the predicted depth by +0.19 ft. If there was no silting at this screen, then the 0.19 ft variance is due entirely to the delay in response time of Pond elevation at the Conowingo Dam to rising water level upstream. Because there is no way to check the variation in elevation between Conowingo and Peach Bottom for both dates, no allowance was made for this error.

FORE-SCREEN DEPTHS
April 1, 1974

Screen	Depth
2	23.58 ft
4	20.83 ft
6	20.83 ft
8	20.42 ft
10	20.67 ft
12	20.50 ft

Reference Elev: 108.41
Error of Reading: ± 0.50 ft
Predicted Depth: 24.41 ft
(with no silting)

River and Pump Conditions
for
Intake Screen Velocity Survey

January 25, 1974	Natural River Flow = 116,100
	Unit 2 - 2 Circulation pumps running.*
	Unit 3 - 1 Circulation pump running.**
April 1, 1974	Natural River Flow = 89,900
	Unit 2 - 3 Circulation pumps running - A, B, C.
	Unit 3 - 1 Circulation pump running - B.

* Circulation pump A was out for maintenance on Unit 2.

** Log does not state which pump was operating.

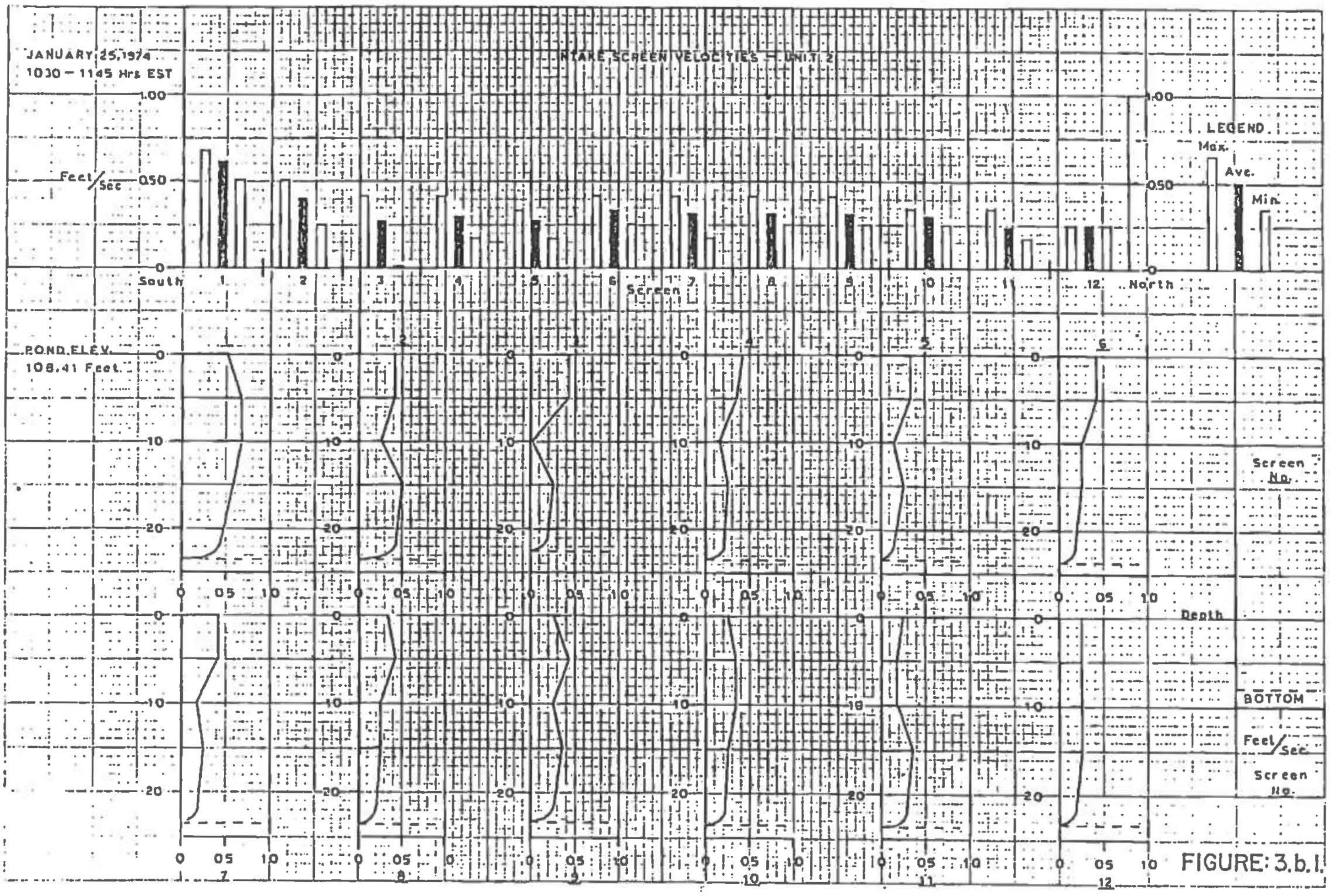

JANUARY 25, 1974
1030 – 1145 Hrs EST
INTAKE SCREEN VELOCITIES – UNIT 2
Feet/Sec
LEGEND
Max.
Ave.
Min.
South
Screen
North
POND ELEV.
108.41 Feet
Screen No.
Depth
BOTTOM
Feet/Sec
Screen No.

FIGURE: 3.b.1.

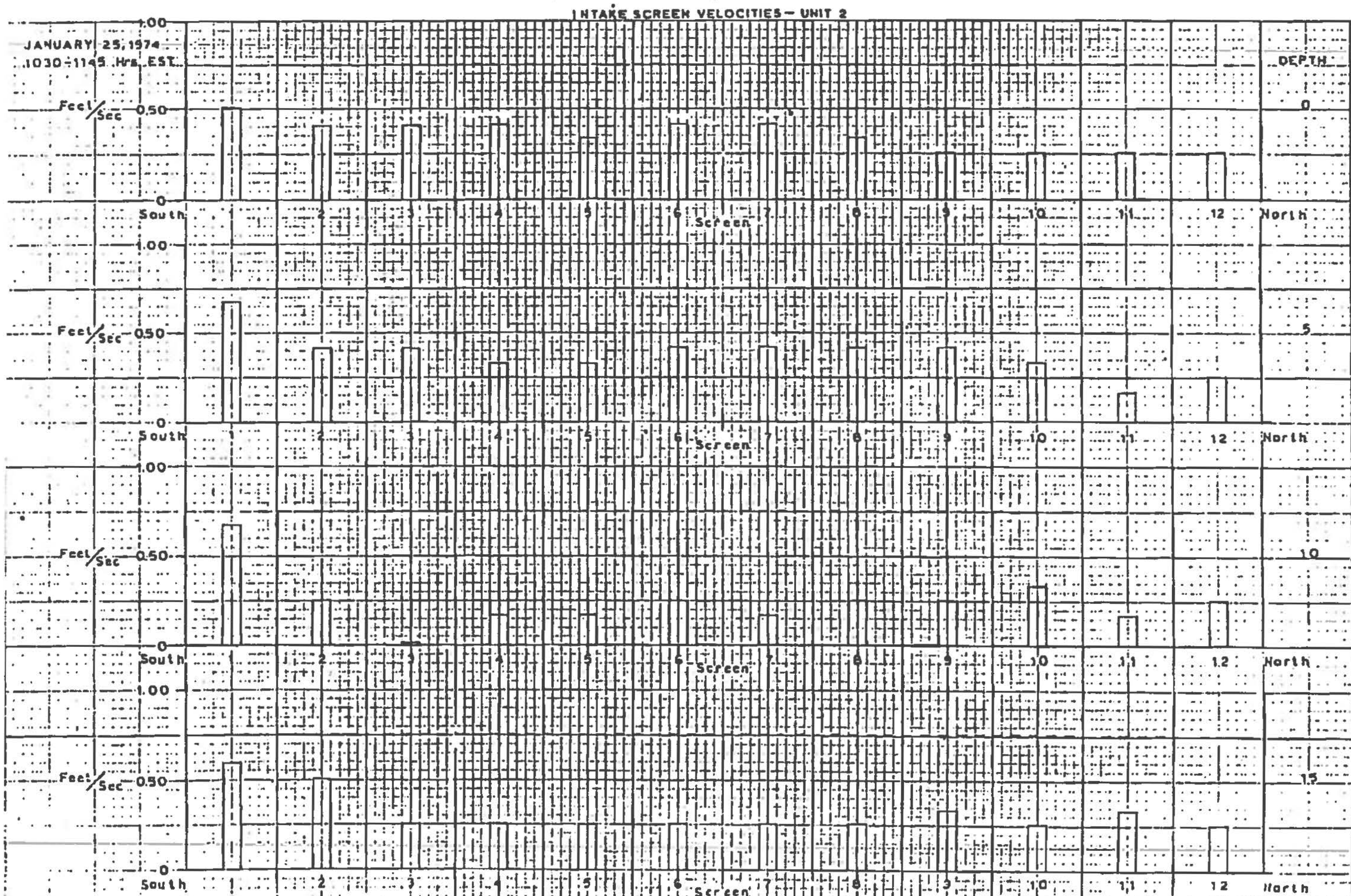

INTAKE SCREEN VELOCITIES — UNIT 2
JANUARY 25, 1974
1030-1145 Hrs. EST
DEPTH
Feet/Sec
1.00
0.50
0
South
1
2
3
4
5
6
Screen
7
8
9
10
11
12
North
0
5
10
15

FIGURE 3.52

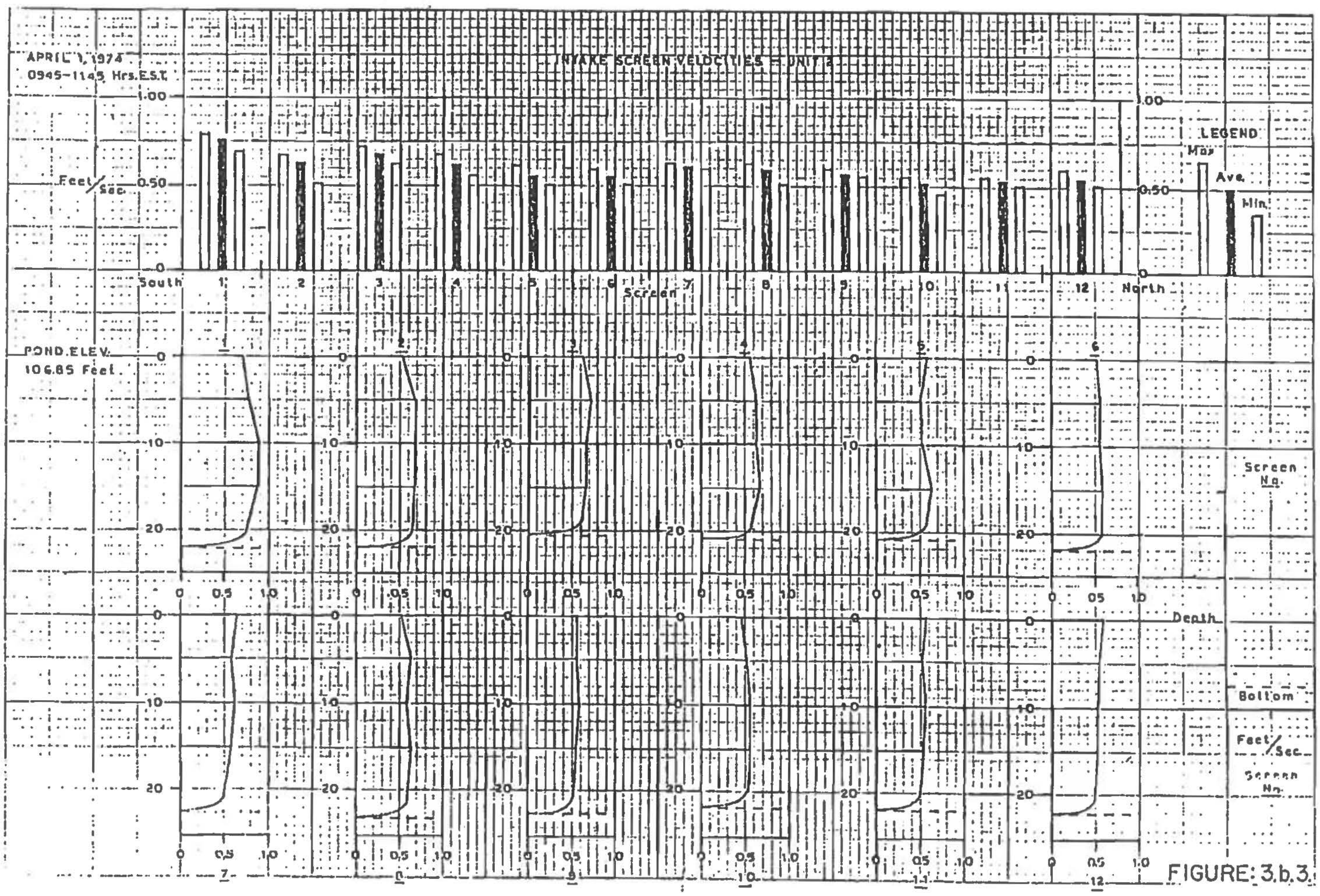

APRIL 1, 1974
0945-1145 Hrs. E.S.T.
INTAKE SCREEN VELOCITIES - UNIT 2
Feet/Sec.
LEGEND
Max.
Ave.
Min.
South
North
Screen
POND ELEV.
106.85 Feet
Screen No.
Depth
Bottom
Feet/Sec.
Screen No.

FIGURE: 3.b.3.

INTAKE SCREEN VELOCITIES – UNIT 2

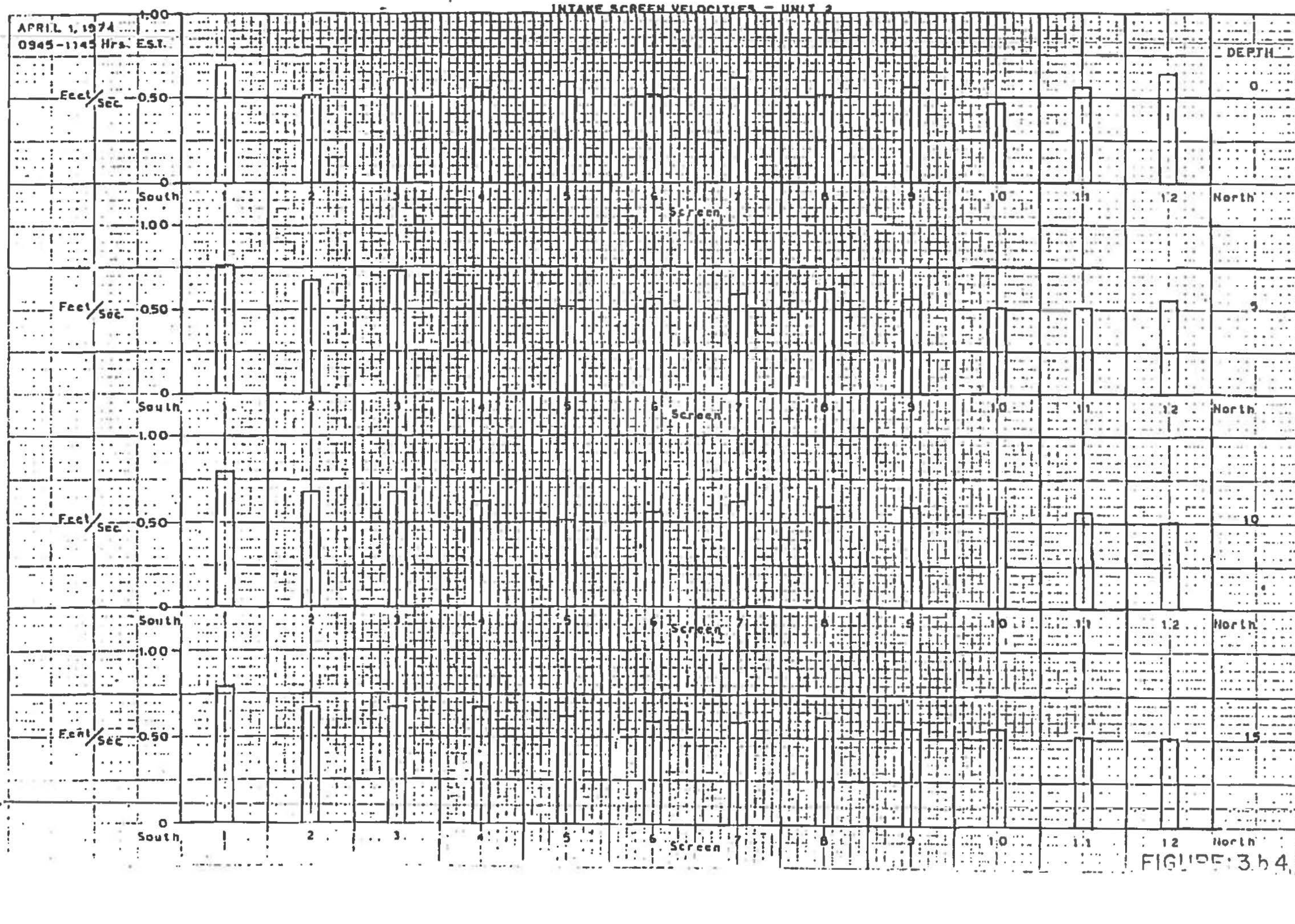


FIGURE 3.b.4

470782

4. RESULTS AND DISCUSSION

Tables 3.b.1 and 3.b.2 summarize the velocities observed on January 25 and April 1. Figures 3.b.1, 3.b.2, 3.b.3, and 3.b.4 show the vertical and horizontal flow distributions on both dates. Table 3.b.3 summarizes the change in Pond elevation on both dates and shows the channel depths that were observed. The channel depths are only an approximation of the silting which has occurred. The fore-screen observations were made by noting the water-line mark on the lead line and therefore may be in error by as much as 1 foot due to water current effects on the lead line. Pond elevations observed on April 1 may be higher than recorded because it was rapidly rising due to the increased river flow and the natural delay in response of Pond elevation from Peach Bottom to Conowingo Hydroelectric Plant where the elevation recordings were taken.

With the survey completed on April 1, 1974 with three circulation pumps running and an average Pond elevation at Conowingo Dam of 106.48 feet, maximum velocity was 0.79 ft/sec (0.47 kts) which was observed at screen #1 (southern-most) at ten and fifteen feet. The average screen velocity for all depths was 0.60 ft/sec (0.35 kts). However the greatest velocities occurred in the southern section, gradually reducing northward to screen #12 with the minimum velocity occurring at screen #10 at the surface which was 0.46 ft/sec (0.27 kts). There appears to be a tendency for the subsurface flows to be slightly higher than the surface, but this is not always the case.

The information gathered on January 25 lends further support to pattern of stronger flows occurring at the southern screens and decreasing velocity the further north a gate is located. On both dates, screen #1 had the maximum velocities. One difference however was the fact that velocities observed on the 25th tended to show a decrease at the 10 foot depth with sometimes an increase in flow at 15 feet. In one case, screen #3, there was almost no trace of current at all. It may have been due to an obstruction caught in the screen which was impeding flow at that depth. With pond elevation at an average level of 108.44, maximum flow was 0.68 ft/sec (0.40 kts), average was 0.33 ft/sec (0.19 kts) and the minimum was a trace for two circular pumps running on January 25th.

Flow directions were westerly, staying within a 20° range. However it was noted that those direction readings taken in the higher numbered screens showed an increased deflection (northerly) the greater the screen number. It was assumed that this northerly deflection of the instrument's compass was caused by the steel separation wall between the intake ponds for Unit 2 and Unit 3 which was nearest screen twelve where the greatest deviation occurred.

5. SUMMARY

In conclusion it appears that the greatest flows will occur along the southern-most screen for Unit 2. There is a marked decrease in flow between this screen and its neighbor. Afterward, the decrease is very gradual. In the vertical plane flows appear to be slightly greater below the surface, although the total range difference does not appear to be greater than 0.17 ft/sec (0.10 kts) with only one exception which may possibly have been due to an obstructed screen. All velocities observed were below 0.79 ft/sec (0.47 kts) and exhibited parallel flow. Bottom silting has occurred on both sides of the screens which may restrict flow and cause slightly higher velocities.

APPENDIX A

Type 110 Remote Reading Current Meter Data Sheet

ENVIRONMENTAL DEVICES CORP.
Marion, Massachusetts 02738

TYPE 110 REMOTE READING CURRENT METER

General Description

The Type 110 Remote Reading Current Meter provides a convenient, reliable, and accurate system to measure current speed, direction, temperature and depth from stationary platforms, moored boats and in other applications which need remote indications in real time. Basically, the Type 110 Remote Reading Current Meter is based on the proven ENDECO*Type 105 Recording Current Meter which was developed specifically for the environmental monitoring field. The Type 110 utilizes the same pressure case and impeller design which has been extensively tested at the Chesapeake Bay Institute of Johns Hopkins University flow channel. In addition, the same all-plastic construction is employed which provides a light weight instrument which is very durable, ideally suited for typical rough handling found in the field.

The Type 110 Remote Reading Current Meter uses sensors which permit telemetering of the data via cable for deck monitoring.

1. Current Speed: A ducted impeller turns in corrosion resistant glass ball bearings running in delrin races. A multipoled magnet axially mounted on the rotor closes a magnetic reed switch four times per revolution within the pressure case. The switch closures are transformed to electrical pulses of fixed amplitude and duration. These pulses are summed using an integrating circuit and drive in output meter at the Deck Readout.

2. Current Direction: Current direction is measured relative to magnetic North using a magnetic compass which is periodically energized by a solenoid to make electrical contact with a potentiometer element. In this way, the compass element is free to rotate with minimum torque requirements and is only momentarily "clamped" to the potentiometer at the time of the reading.

3. Depth: Depth is sensed using a pressure operated potentiometer. The voltage developed across the potentiometer is sensed by the pressure-activated wiper and is transmitted via cable to the Deck Readout.

4. Temperature: Temperature is measured using a linear glass bead thermistor element, mounted in potted assembly, mounted on the pressure case and in direct contact with the water medium. Data is transmitted via cable to the Deck Readout.

5. Recorder Output: An optional recorder output is available upon request. The Type 110 Deck Readout provides a convenient means to monitor the output of the Type 110 Current Meter.

* Trade Mark

The readout unit provides the necessary power to drive the circuitry within the Readout and Current Meter. Eight 1.5 volt "D" cell batteries provide a 12 volt D.C. power supply for many months of typical operation.

The Type 110 Deck Readout contains 2 readout meters. One is for monitoring current speed and direction. A second meter is used for monitoring temperature and depth. Current speed is continuously indicated when direction is not being sampled. Direction is sampled using a push button switch. The Deck Readout is packaged in a water resistant carrying case.

The Type 110 sensor package and Deck Readout units are interconnected using a 10-conductor polyurethane covered cable. Cable lengths of up to 500 feet may be used without adjustments of the readout circuit. Longer lengths may be used with adjustments of the circuitry.

The telemetering cable enters the instrument through a packing gland below the nose of the instrument. No electrical swivel is required since the flexible service cable allows up to five revolutions of the instrument without strain on the cable or restraint of the sensor package. A weight may be attached to the base of the instrument tether to depress the current meter. The weight is free to pivot using a swivel which is incorporated in the tether assembly.

Detailed Specifications

TYPE 110 REMOTE READING CURRENT METER:

Current Speed Sensor:	Ducted Impeller/reed switch with voltage readout.
Range:	0 to 5 knots
Accuracy:	±3% of Full Scale
Threshold:	Less than .05 knots (1.9 cm./sec.)
Current Direction Sensor:	Magnetic Compass with potentiometer for monitoring pressure case orientation relative to magnetic north.
Range:	0 - 360° (0 - 357° Electrical)
	±3% of Full Scale
	.05 knots
Depth Sensor:	Pressure operated potentiometer
Range:	0 to 1000 feet. Other ranges available.
Accuracy	±2% of Full Scale
Overpressure:	1.5 x Full Scale
Isolation:	Oil filled isolation with neoprene diaphragm.
Temperature Sensor:	
Type:	Linear Glass Bead Thermistor
Range:	0° to 40°C
Accuracy:	±0.5°C

Operating Environment

Operating Medium:	Salt, fresh or polluted water.
Operating Temperature Range:	0° to 40°C (32° to 104°F)
Storage Temperature Range:	-34 to 65°C (-30 to 149°F)
Maximum Pressure:	500 psi (Pressure cases to 10,000 psi available)
Maximum Mooring Tensile Load:	250 pounds

Instrument Housing

Material:	All plastic
Finish:	Painted with anti-fouling surface.
Hardware:	300 Series Stainless Steel

Physical Size (Sensor Package)

Weight:	35 pounds (in air)
Weight in sea water:	Approximately neutral.
Dimensions:	See outline drawing.
Shipping weight:	Approximately 40 pounds.
Shipping dimensions:	38" long x 22" diameter

TYPE 110 DECK READOUT

Readout Meters:	6" square
Meter Calibrations:	0 to 5 knots: Speed 0 to 360° Magnetic North: Direction 0 to 40°C: Temperature 0 to 100 feet: Depth
Batteries:	8, 1-1/2 volt "D" cells

Operating Environment

Operating Medium:	For use on board small boats.
Operating Temperature Range:	0°C to 40°C (32°F to 104°F)
Storage Temperature Range:	-35°C to 65°C (-30°F to 149°F)

Deck Readout Housing

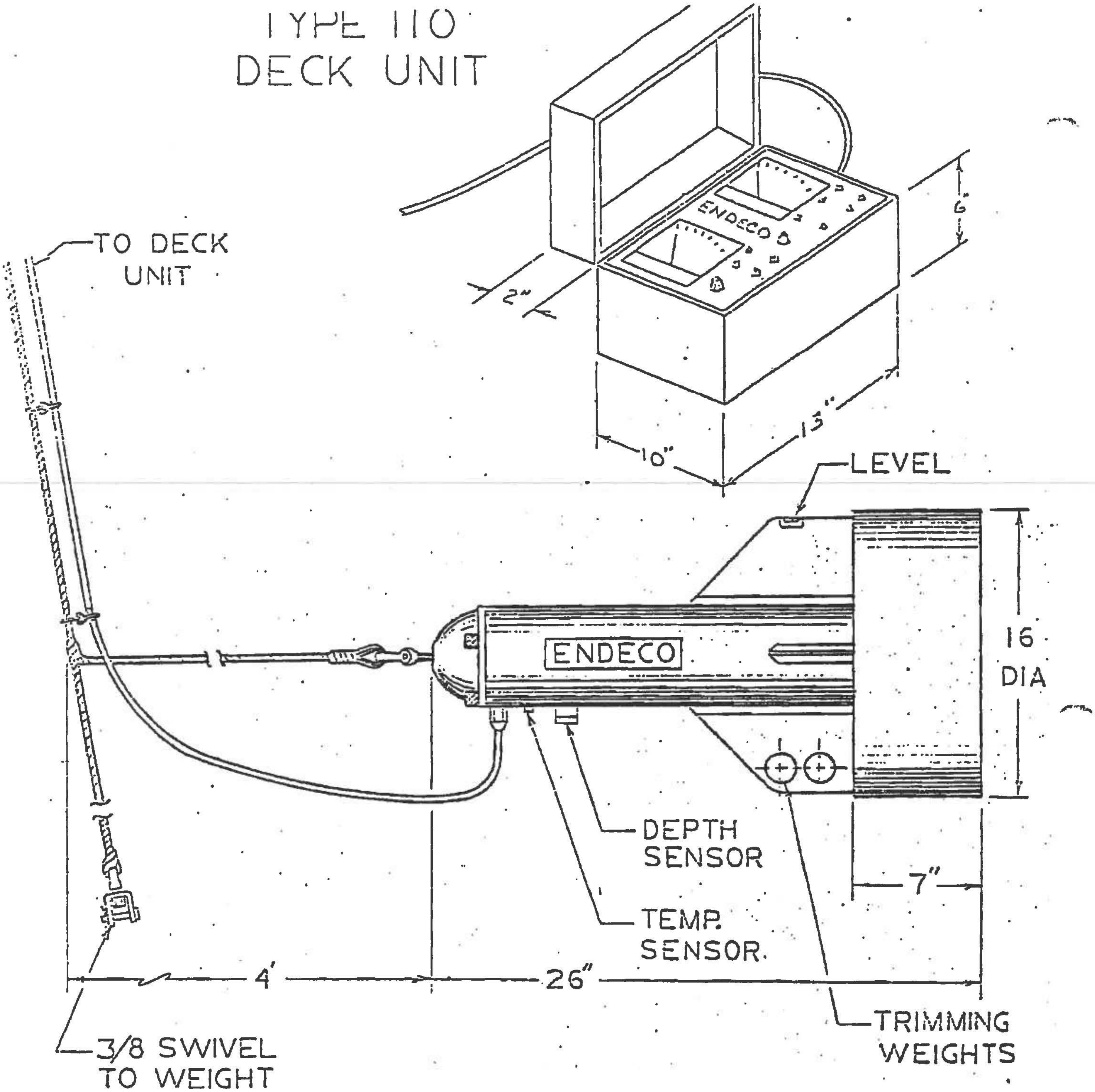
Material:	Corrosion resistant formica case.
Hardware:	300 Series Stainless Steel and chromed plate brass.

Physical Size

Weight:	Approximately 14 pounds.
Dimensions:	10" high x 13" wide x 10" deep.
Shipping Weight:	Approximately 30 pounds.
Shipping Dimensions:	17" x 20" x 17"

For further information contact:

Environmental Devices Corp.
Instrument Division
Tower Building, Marion, Massachusetts 02738
Telephone: 617-748-0366



TYPE 110 REMOTE READING
CURRENT METER

A100281 REV. 1.