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Non-Radiological Consequences to the Aquatic Biota and Fisheries of the Susquehanna River from the 1979 Accident at Three Mile Island Nuclear Station

C. R. Hickey, Jr., R. B. Samworth

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ABSTRACT

The non-radiological consequences to the aquatic biota and fisheries of the Susquehanna River from the March 28, 1979 accident at Three Mile Island Nuclear Station were assessed through the post-accident period of July 1979. Thermal and chemical discharges during the period did not exceed required effluent limitations. Several million gallons of treated industrial waste effluents were released into the river which were not of unusual volumes compared with normal operation and were a very small proportion of the seasonally high river flows. The extent and relative location of the effluent plume were defined and the fishes known to have been under its immediate influence were identified, including rough, forage, and predator/sport fishery species.

No impacts to benthic invertebrates or fishes were detected. No unusual conditions of fish disease or mortalities were noted. Normal seasonal increases in faunal abundance and species composition occurred, as did the onset of the fish spawning season in April with peaks of ichthyoplankton abundance in May and June.

Post-accident recreational fishing patterns in the vicinity of Three Mile Island departed from historical trends. Fishing appeared to partially shift emphasis from the reservoir proper near the nuclear station to other areas, especially downstream. Anglers fished relatively less in the reservoir and returned greater proportions of their catches than during any corresponding

time period within the previous five years. This was most notable during April when anglers returned an unprecedented 100% of their catches. With time following the accident, the patterns of recreational fishing returned to normal or near-normal.

Several generic aspects of this investigation are discussed, including: the occurrence of the accident with respect to the biological season, and the ability to detect an impact; data availability and data needs for assessment; and the application of these non-radiological findings for radiological impact assessment.

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EXECUTIVE SUMMARY

1. The non-radiological consequences to the aquatic biota and fisheries of the Susquehanna River from the March 28, 1979 accident at Three Mile Island Nuclear Station were assessed through the post-accident period of July 1979. Data utilized in the study included site specific biological and water quality information collected by the Licensee and his consultants during operational monitoring at Units 1 and 2, beginning in 1974 and continuing through the period of study. Data were also available through the Commonwealth of Pennsylvania NPDES monitoring program, from the U. S. Geological Survey, from knowledgable persons within state and federal agencies, and from aquatic biological studies conducted in other upstream and downstream areas of the Susquehanna River.

2. During and following the accident, the ΔT and discharge temperatures at the river discharge never exceeded thermal limitations imposed by the Commonwealth of Pennsylvania. The thermal discharges were all within the values reviewed and found to be acceptable in preoperational NEPA assessments, including the 1972 NRC FES, the 1976 NRC Final Supplement to the FES, the 1977 Unit 2 environmental hearing. Similarly, the concentrations of chemical substances released during the period never exceeded NPDES limitations and were within the values reviewed and found to be acceptable in preoperational assessments. The several millions of gallons of treated industrial waste effluents released into the river were not of unusual volume compared with normal operational releases and

were very small in volume relative to the seasonally high river flow during that time.

3. Utilizing data collected during operational thermal plume mapping surveys (1974-1978), the relative location of the effluent plume, and thus that portion of the receiving waters under its immmediate influence, were identified. The effluent plume has been confined to very near the west shoreline of Three Mile Island. Its maximum measurable extent has been to distances less than 20m offshore and 1000m (about 0.6 mile) downstream, or to a point about halfway between the discharge and the junction of the York Haven Dam with Three Mile Island.

4. Since thermal and chemical effluents did not violate established limitations and were within previously assessed values, impacts to aquatic biota were not expected. An examination was conducted of biotic conditions in the river during the period of the accident and compared with historic conditions. No effects to benthic invertebrates or fishes were detected. No unusual conditions of fish disease or mortality were noted in the river following the accident. The normal spring increases in faunal abundance occurred, as did the onset of the fish spawning season in April with ichthyoplankton peaks during May and June. Sampling with several gear types in the immediate effluent plume area documented the presence of many fish species including rough (carp, suckers), forage (shiners, darters), and predator/sport (bass, sunfishes, walleye) species.

5. Post-accident recreational fishing patterns in the site vicinity departed from historical trends. Fishing appeared to partially shift away from the reservoir in the immediate site vicinity to other areas, especially downstream to the York Haven Dam and the hydroelectric station. Anglers fished relatively less in the reservoir and those who did fish there returned greater proportions of their catches than during any corresponding time period within the previous five years. This was most notable during April 1979, when anglers in the reservoir returned an unprecedented 100% of their catches. With time following the accident, the patterns of recreational fishing returned to normal or near-normal.

6. Several generic aspects realized from this study were noted, including:

   a. A realization that thermal and chemical effluents during the accident could be maintained within acceptable levels, thus minimizing the potential for impact to aquatic biota.
   b. The occurrence of the accident during a biological season when impacts might have been most detectable, had they occurred. This possibility plus the availability of detailed site specific data for evaluation of impact permitted a realistic assessment and a reasonable conclusion of no impact. This conclusion supports that expected from the non-violation of thermal and chemical discharge limits, and might be expected to result (in general) following accidents (of the type experienced at Three Mile Island) in which similar limitations are not violated.

c. The data needs and data availability for assessing impacts were examined, on the premise that the situation which occurred at Three Mile Island probably represented a best-case with respect to the presence of several recent years of detailed studies which continued through the period of the accident. Environmental monitoring required by both the ETS and NPDES permit were essential elements in realistically assessing impacts. A scenario was developed for accidents (or any non-accident events of potential ecological significance) which occur many years after the cessation of detailed site specific studies and considered how the lack of such data could affect the ability to realistically assess the impacts. Means for coping with this situation were explored including: periodic goal oriented monitoring for updating specific types of information; goal oriented operational monitoring during the early years of reactor life; the types of information which likely could be obtained following an accident which occurs many years into station life and for which no site specific studies have been conducted for many years.

7. Several findings of this non-radiological study are applicable to the assessment of the potential radiological consequences of the Three Mile Island accident, and to radiological assessment in general. They are as follows:

a) The identification of the immediate extent and relative location of the effluent plume could be useful in defining the immediate impact area for collecting radiological samples of river water and

sediments and aquatic biota which might have received doses prior to significant effluent dilution with river flows.

b) The identification of several components of the fish community (rough, forage, predator/sport) in the immediate effluent plume area could be useful for defining fishes to be studied for radiological purposes.

c) The identification of fish disease and mortality conditions by type and species, as known from the site vicinity historically and following the accident, could be used for comparison and followup after an accident or radiological release event for short-term (mortalities) and long-term (disease) effect studies, as potentially causally related to the releases.

d) Examination of the recreational fishery in the site vicinity following the accident showed that fishing partially shifted from the immediate site vicinity (the reservoir) to other areas. During the first month following the accident (April 1979) anglers fishing in the reservoir proper were noted as having kept none of their catches. This suggests that the liquid radiological pathway leading to man via finfish consumption was absent in the immediate receiving waters of the station effluents. As such, a form of voluntary pathway interdiction might have been exercised by the anglers.

I. INTRODUCTION AND OVERVIEW

The Three Mile Island Nuclear Station is located in Dauphin County on the York Haven Pond (Lake Frederic) of the Susquehanna River approximately 10 miles (6.2 km) downstream (southeast) from Harrisburg, Pennsylvania. The station consists of two closed-cycle cooling steam electric generating units (Figure 1). Initial reactor criticality was achieved at Unit 1 (871 MWe) on June 5, 1974 and at Unit 2 (959 MWe) on March 28, 1978. Unit 2 was designated to be in commercial operation on December 30, 1978[1/].

On March 28, 1979, Unit 2 was operating at 97 percent of full power when it experienced a loss of normal feedwater supply that led to a turbine trip and later to a reactor trip. Subsequently, a series of events occurred that resulted in significant damage to portions of the reactor core. During the early phases of the accident, the reactor coolant system experienced high temperatures, at one point in excess of 620°F (~327°C). After about 15.5 hours, the core coolant temperatures decreased to about 280°F (~138°C). Heat was transferred through one steam generator to the main condenser and then to the atmosphere and river by the circulating cooling water system. The reactor remained in that condition, but with decreasing temperature during the next several weeks, and on Friday April 27, 1979, the unit was placed in a natural circulation cooling mode with heat removal through the steam generator[2/]. Unit 1 began a shutdown for refueling on February 16, 1979, and was in a cold shutdown mode at the onset of the Unit 2 accident.

The nuclear incident was of critical public concern due to health and safety considerations and much documentation of these matters has already occurred. A detailed list through May 21, 1979 of available preincident and postincident documents is published [3], as well as several postincident NRC assessments of health and safety related matters [2] [4] [5] [25] [51] [56] [58].

It is the intent of this report to examine the non-radiological consequences to the aquatic biota of the Susquehanna River in the vicinity of Three Mile Island during and following the accident. Since the incident was a unique occurrence, it is important and useful to document the non-radiological operational characteristics of the station which potentially could affect the river biota and to cite the sources of available information for such an examination. This report will examine station operation during the period of the accident in relation to normal operation and to previous impact assessments of operation on Susquehanna River biota. Aquatic ecological studies of the river in the vicinity of Three Mile Island have been ongoing for several years and have formed the bases for impact assessments in the 1976 NRC Final Supplement to the Final Environmental Statement [6] and during the 1977 environmental hearings before the NRC Atomic Safety and Licensing Board in Harrisburg. It is not the intent of this report to describe or summarize all the studies which have occurred or which are ongoing, since most of the studies already are summarized or evaluated in several documents, including the FES [6], hearing testimony [7] [8] [9], and the current Environmental Technical Specifications (ETS) and their companion Environmental Program Description Document for operation of Unit 2. It is the intent to reference the pertinent

recent studies and assessments and to present data collected during the periods immediately before and following the accident so that their availability and general content might be known by interested private, public, and governmental concerns. The findings and generic aspects will then be discussed in a broader sense, along with the applicability of the non-radiological findings to radiological assessments.

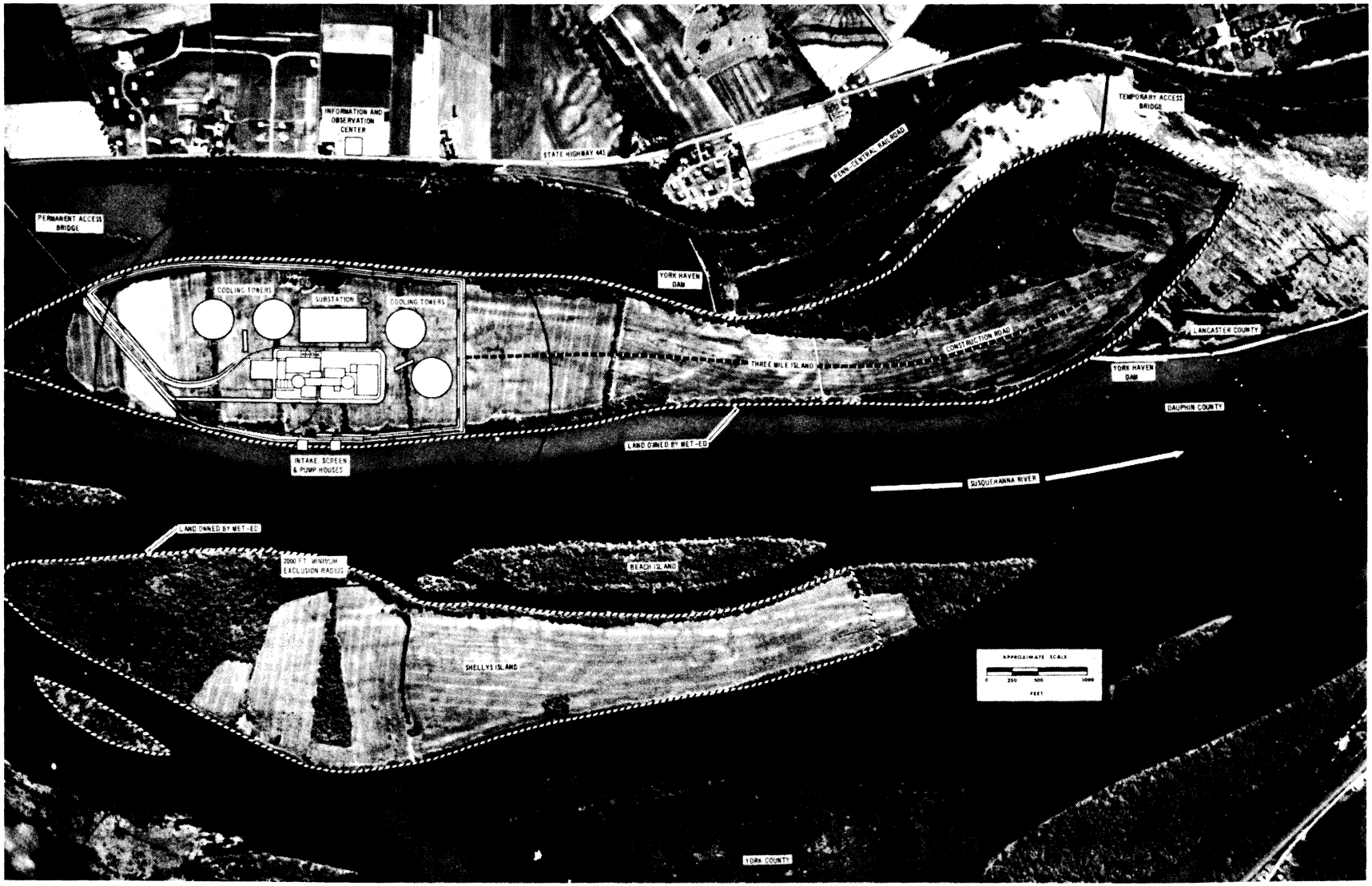

FIGURE 1. THE THREE MILE ISLAND NUCLEAR STATION SITE ON THE SUSQUEHANNA RIVER, PENNSYLVANIA (Ref.No.10).

II. NON-RADIOLOGICAL ASPECTS OF STATION OPERATION AND WATER QUALITY IN THE SUSQUEHANNA RIVER

The aspects of station operation during the accident which potentially could have affected the aquatic biota of the Susquehanna River are related to thermal and chemical discharges. During the NRC review of the potential impacts of operation of Unit 2 on the Susquehanna River, the water quality conditions as they existed then were examined[6/]. The water quality of the river was found to be generally good. Parameters of concern in the Three Mile Island site vicinity included nutrients, iron, pH, sulfate, and coliform bacteria concentration. Typical values of these and other parameters in the river near the site for the period June 1967 through August 1974 are shown in Table 2.4 of the FES [6/]. The NRC NEPA review [6/] examined several water quality parameters of the nuclear station discharge that were of concern either because of their potential for adverse affects in and of themselves or in concert with conditions in the receiving waters. Included were: sulfate (from station demineralizers and concentration effects in the closed-cycle cooling system); copper and zinc (from erosion products of the heat exchangers in the cooling waters); residual chlorine (from biofouling control); temperature; total dissolved solids; and alkalinity and pH. Data on these parameters are available from ongoing monitoring programs at Three Mile Island, as required by the Commonwealth of Pennsylvania NPDES Permit PA-0009920 and the USNRC Environmental Technical Specifications (Appendix B to the Facility Operating Licenses for Units 1 and 2). These data are discussed below in relation to normal station operation, applicable permit limits and discharge standards, and to relevant previous studies and analyses.

A. Thermal Discharges

Both units of the nuclear station utilize hyperbolic natural draft cooling towers (two towers per unit) for dissipating the heat rejected from the steam cycle. Additionally, all of the cooling water effluent from the station is passed through mechanical draft cooling towers (one per unit) prior to discharge to the river [10]. Each unit utilizes a separate shoreline cooling water intake structure, but both units discharge through a common shoreline structure (Figure 2). Water withdrawal requirements (for both units combined) are approximately 54,500 gpm (~122CFS; 78.5×10^6 GD) for cooling tower makeup [6] during normal operation. Of that volume, approximately 36,000 gpm (~80.4 CFS; 51.8×10^6 GD) on an annual average is discharged to the river, with the remainder lost through cooling tower evaporation. During reactor cooldown, approximately an additional 10,000 gpm (22.3 CFS) of river water can be provided to each unit [31].

During normal winter operation, cooling tower effluent is discharged to the river at a ΔT of approximately 3°F(1.7°C) and a flow of about 80 CFS. During a normal cooldown (cooling of the reactor primary coolant loop by the nuclear decay heat system following a reactor shutdown), the discharge ΔT at hour 0 could be about 12°F(6.7°C) at a flow of about 113 CFS and at hour 12 return to about 3°F(1.7°C) at 113 CFS [6] [9].

Since Unit 1 became operational in 1974, the following maxima and minima of temperatures and ΔTs at the discharge have been recorded:

	Discharge Temp. (°C)		ΔT (°C)	
Year	Low	High	Low	High
1974 [11]	4.9(Dec 17)	27.5(Jul 19)	-5.6(Jul 17)	+3.9(Dec 3)
1975 [12]	3.3(Feb 4)	30.0(Aug 14)	-0.2(Aug 6)	+5.2(Mar 5)
1976 [13]	2.8(Feb 21)	25.8(Aug 26)	-2.8(Jun 2)	+4.7(Feb 16)
1977 [14]	2.6(Nov 29)	29.9(Jul 21)	-5.9(Sep 15)	+2.5(Dec 8)
1978	<0.1(Jan)[32]	31.7(Jul 21)[32]	-0.5(Jun 23)[15]	+1.7(Jul 14)[15]

During actual normal cooldown operations at Unit 1, the following temperature conditions have been recorded:

Date	Max. Effluent Rate (CFS)	High ΔT (°C)	Low ΔT (°C)
Feb 20-21, 1976[13]	115.9	+4.7	+1.4
Mar 19-20, 1977[14]	115.85	+1.7	-0.1

The Commonwealth of Pennsylvania NPDES Permit requires monitoring of the effluent discharge temperature and ΔT, with results to be reported in

monthly discharge monitoring reports (DMR). Discharge Temperature and ΔTs for the period during (beginning March 28) and following the accident were reported to the Commonwealth in the DMRs for March [16] and April [17] 1979 and are presented here as Tables 1 and 2. During the accident and through April 27 (when the natural circulation cooling mode began) the recorded temperatures were as follows:

	Minimum	Maximum
Discharge Temperature (°F)	41.8	65.4
Discharge Temperature (°C)	5.4	18.6
ΔT (°F)	-1.3	+4.7
ΔT (°C)	-0.7	+2.6

Discharge volumes ranged from a maximum of 106.6 MGD (165.2 CFS) on March 31 (Table 3)[16] to a minimum of 61.3 MGD (95.0 CFS) on April 22 (Table 4)[17]. These values include the combined effluents of Units 1 and 2.

The Commonwealth of Pennsylvania's Water Quality Certification under Section 401 of PL 92-500 (dated November 9, 1977) for Three Mile Island Nuclear Station contains the following five criteria with respect to thermal discharges:

1. "The temperature of the discharge shall never exceed a maximum of 87°F[30.6°C], except when the ambient river temperature exceeds

87°F, in which case, the discharge temperature shall not exceed the ambient river temperature" (Section 3.c.2.b);

2. "The temperature of the discharge shall not change by more than 5°F[2.8°C] during any one hour period" (Section 3.c.2.b);
3. "During the period November 1 through April 30, the temperature of the discharge shall not exceed 12°F[6.7°C] above ambient river temperature" (Section 3.c.2.c.1);
4. "During the period May 1 through October 31, the temperature of the discharge shall not exceed 7°F[3.9°C] above ambient river temperature" (Section 3.c.2.c.2);
5. "During plant cooldown operations, the temperature of the discharge shall not exceed 12°F[6.7°C] above ambient river temperature" (Section 3.c.2.c.3).

During and following the accident, none of the above thermal criteria were violated, and in fact, the ΔTs generally were smaller than during most of the month of March preceding the accident. The only potential noncompliance with thermal criteria which occurred during 1979 preceding the accident was on 21-22 March when maximum ΔTs of 13.0°F and 15.1°F were reported (Table 1). Investigation by the licensee revealed that the instrumentation used to determine the temperature differential was not operating correctly at that time, and the actual ΔTs were approximately 2°F. Action was taken to correct the faulty instrumentation [18]. Thermal discharges during and following the accident also were within the required limits of the NRC ETS and were within the values reviewed in previous evaluations [6] [9] [10] [19].

The accident at Three Mile Island was described as a feedwater transient* which led to a small break loss-of-coolant accident which resulted in damage to portions of the reactor core [2]. Core damage resulted from overheating due to the generation of heat from the fission process at a rate faster than it was being removed by the cooling system. Nuclear fuel is subjected to heating due to absorption of energy from the decay of radioactive materials and this heating continues even after a reactor is shutdown. Decay heat can be a source of overheating in fuel in a shutdown reactor or in fuel that has been removed from a reactor. Immediately following shutdown of a reactor that has operated about a month or longer, the heat from radioactive decay heat amounts to about 7%

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*The Reactor Safety Study (Ref. No. 20) states that in general, the term reactor transient applies to any significant deviation from the normal operating value of any of the key reactor operating parameters. Transient events include all those situations which could lead to fuel heat imbalances, and transients cover the reactor in a shutdown condition as well as in the various operating conditions. The shutdown condition is important because many transient conditions result in shutdown of the reactor, and decay heat removal systems are needed to prevent fuel heat imbalances due to core heat decay. In safety analyses, the principal areas of interest are: increases in reactor core power (heat generation); decreases in coolant flow (heat removal); and reactor coolant system pressure increases. All of these represent a potential for damage to the reactor core.

of that produced during operation [20]. During the Three Mile Island accident, the heat production in the core was decay only a few percent of that produced during normal full power operation, but overheating resulted from an inability to remove the relatively small amount of decay heat at the proper rate for normal core cooling. During the accident, then, the rejection of heat from the reactor cooling system to the river via the condenser cooling system was not greater than normal, as one might suspect from knowledge that the reactor core was experiencing overheating difficulties. During normal full power operation, the rate of heat transfer to the condenser cooling system essentially is near maximum.

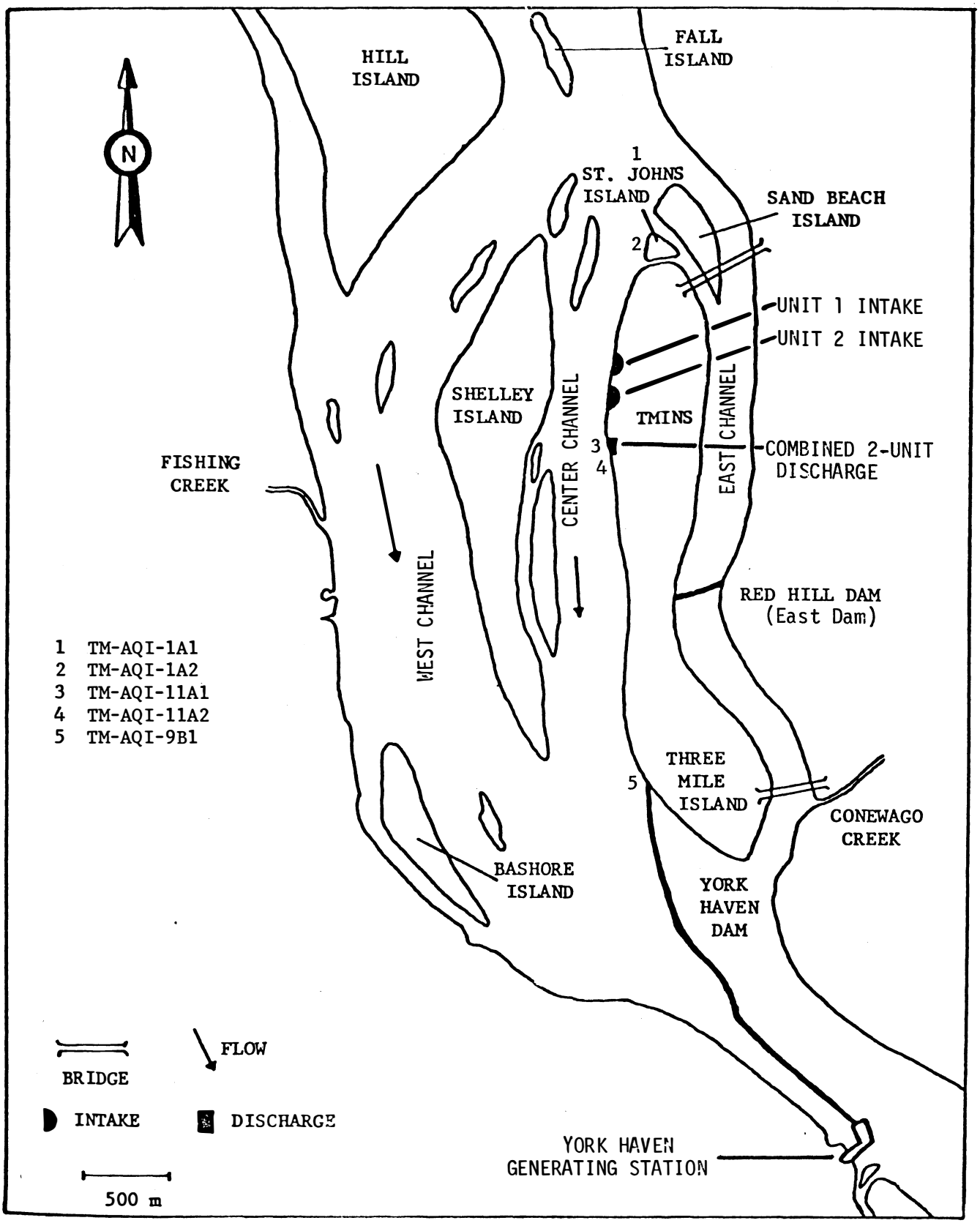

FIGURE 2. LOCATION OF WATER QUALITY AND MACROINVERTEBRATE SAMPLING STATIONS IN THE SUSQUEHANNA RIVER NEAR THREE MILE ISLAND NUCLEAR STATION. (Ref.No.15).

TABLE 1
(Ref.No.16)

THREE MILE ISLAND NUCLEAR STATION
MONTHLY OPERATING REPORT
MAIN DISCHARGE
THERMAL DISCHARGES
MARCH 1979

Parameter	Chlorine						T. Min		T. Avg		T. Max		
Units	mg/l						°F		°F		°F		
Sample Type	Grab						Meas.		Meas.		Meas.		
Frequency	3/Day for 1 Chlorination						Daily		Daily		Daily		
Date	Total	Free	Total	Free	Total	Free	Eff.	ΔT	Eff.	ΔT	Eff.	ΔT	
3/01/79	OUT OF	SERVICE	ENTIRE	MONTH			36.9	+4.5	38.6	+5.5	40.0	+6.9	
02							38.1	+4.0	40.0	+5.3	42.2	+7.2	
03							39.2	+3.0	40.7	+4.7	42.7	+6.7	
04							41.5	+5.7	43.0	+7.0	44.8	+9.5	
05							44.5	+8.1	45.6	+9.3	46.7	+10.3	
06							41.3	+4.4	43.7	+7.0	45.6	+9.2	
07							39.6	+2.9	40.8	+4.2	41.8	+5.1	
08							39.2	+3.6	40.8	+4.7	42.1	+5.8	
09							39.2	+3.6	41.0	+5.0	42.5	+6.2	
10							39.2	+3.6	41.5	+5.6	43.6	+7.4	
11							38.2	+1.7	39.8	+3.6	42.1	+6.1	
12							39.2	+3.5	40.0	+4.1	41.3	+5.1	
13							39.2	+3.5	41.2	+5.2	43.9	+7.6	
14							40.9	+4.2	43.9	+7.4	46.0	+9.6	
15							38.4	+2.9	42.4	+6.3	46.0	+9.6	
16							38.5	+3.3	40.0	+4.1	41.1	+5.1	
17							39.8	+3.7	42.1	+5.8	44.1	+7.6	
18							42.7	+6.3	43.9	+7.2	45.5	+8.6	
19							42.9	+6.5	44.3	+8.0	45.5	+9.3	
20							43.6	+7.3	45.3	+8.8	48.1	+11.6	
21							43.8	+7.1	46.7	+10.0	49.8	+13.0	*
22							44.9	+8.3	48.3	+11.7	51.8	+15.1	*
23							46.9	+4.3	50.6	+5.6	53.8	+6.0	
24							53.3	+4.0	54.1	+4.7	54.7	+4.9	
25							50.3	+2.1	51.8	+3.0	53.7	+4.4	
26							43.0	-3.0	46.3	+0.5	48.1	+2.1	
27							46.0	+1.3	47.4	+2.7	48.6	+3.5	
28		BEGIN		ACCIDENT			44.4	+0.9	46.0	+1.7	47.4	+2.5	
29							46.3	+1.5	48.2	+2.9	50.1	+4.3	
30							49.3	+2.8	50.4	+3.9	51.6	+4.8	
31							50.7	+3.4	51.9	+4.1	53.1	+4.7	

* PaDER informed by letter dated 4-6-79 regarding the accuracy of this data.

TABLE 2
(Ref.No.17)

THREE MILE ISLAND NUCLEAR STATION
MONTHLY OPERATING REPORT
MAIN DISCHARGE
THERMAL DISCHARGES
APRIL 1979

Parameter	Chlorine						T. Min		T. Avg		T. Max	
Units	mg/l						°F		°F		°F	
Sample Type	Grab						Meas.		Meas.		Meas.	
Frequency	3/Day for 1 Chlorination						Daily		Daily		Daily	
Date	Total	Free	Total	Free	Total	Free	Eff.	ΔT	Eff.	ΔT	Eff.	ΔT
April 1, 1979	----------OUT OF SERVICE ENTIRE MONTH----------						50.9	+2.2	52.1	+3.1	53.2	+3.5
2,							50.0	+1.1	50.8	+1.8	52.1	+2.4
3,							49.2	+1.6	50.0	+2.3	50.4	+2.9
4,							47.2	+0.7	47.8	+1.2	49.0	+1.8
5,							46.7	+1.2	48.0	+1.6	48.2	+1.9
6,							43.3	-1.3	45.1	-0.3	47.1	+1.5
7,							41.8	-0.6	43.5	+0.1	44.7	+0.9
8,							43.6	+0.4	44.3	+1.1	44.8	+2.0
9,							43.6	+1.7	44.3	+2.1	44.8	+2.6
10,							43.0	+1.6	44.8	+2.1	46.6	+2.4
11,							45.4	+1.4	47.3	+2.5	48.8	+3.3
12,							47.1	+2.9	47.9	+3.4	48.5	+3.8
13,							44.6	+1.6	45.8	+2.6	47.3	+3.8
14,							44.7	+1.7	46.4	+2.1	48.4	+2.6
15,							47.7	+1.3	48.4	+1.8	48.8	+2.5
16,							47.2	+1.2	47.4	+1.6	47.7	+2.0
17,							46.8	+1.5	47.2	+1.7	47.6	+1.9
18,							47.0	+0.9	48.4	+1.4	50.0	+1.8
19,							48.2	+0.5	49.7	+1.0	51.6	+1.7
20,							49.0	+0.1	51.2	+1.1	53.0	+1.8
21,							50.8	+0.4	53.6	+1.4	56.1	+2.2
22,							53.8	+1.2	55.9	+1.9	58.1	+2.9
23,							56.7	+1.4	58.5	+2.0	60.3	+2.7
24,							58.6	+1.0	60.4	+1.6	62.3	+2.3
25,							61.1	+2.0	63.1	+2.4	65.2	+2.9
26,							63.7	+1.5	64.3	+1.9	65.4	+2.2
27,		NATURAL			CIRCULATION		60.7	+0.2	63.2	+1.4	64.1	+2.1
28,							58.7	-0.7	60.6	+0.2	63.3	+0.6
29,							57.6	-0.8	60.0	-0.2	61.3	+0.5
30,							58.3	-0.3	60.7	+0.4	62.6	+1.0

TABLE 3
(Ref.No.16)

THREE MILE ISLAND NUCLEAR STATION
MONTHLY OPERATING REPORT
MAIN DISCHARGE
CHEMICAL DISCHARGES
MARCH 1979

Parameter	Volume	pH		TSS		TDS		Total FE		Oil & Grease
Units	10^6 Gal.	Standard Units		mg/l		mg/l		mg/l		mg/l
Sample Type	Meas.	Grab		Grab		Grab		Grab		Grab
Frequency	Daily	Weekly		Weekly		Weekly		Weekly		Weekly
Date	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Eff.
3/01/79	63.9	6.75	7.35	13	88	184	215	1.08	3.65	
3/02/79	56.3	7.58	7.23	84	94	183	348	1.21	2.98	
3/03/79	59.8									
3/04/79	66.7	6.6	6.9	30	21	83	182	1.00	2.59	
3/05/79	69.7	6.7	7.4	7	44	99	112	0.83	1.41	
3/06/79	74.1	6.72	7.25	7	90	110	97	1.42	5.18	
3/07/79	69.6	6.8	6.75	311	117	124	104	19.3	7.86	
3/08/79	76.3									
3/09/79	72.7	6.8	6.85	30	190	115	95	3.35	6.69	
3/10/79	77.0	6.9	7.12	172	210	101	124	8.7	9.87	
3/10/79		6.90	7.2	136	128	110	113	8.63	6.87	
3/11/79	50.5									
3/12/79	70.0	7.17	7.4	75	76	92	123	3.72	4.93	
3/13/79	69.6	6.95	7.23	27	22	111	161	3.15	3.62	
3/14/79	65.6	7.19	7.23	33	34	158	148	3.95	4.14	
3/15/79	63.1	7.05	7.3	41	50	235	121	3.83	4.67	
3/16/79	79.6	7.21	7.39	19	58	110	179	0.36	0.48	
3/17/79	63.8	7.23	7.29	17	40	125	150	2.38	3.08	
3/18/79	57.3	7.25	7.27	24	52	151	144	2.78	3.09	
3/19/79	69.2	7.01	7.12	28	35	120	167	1.61	1.14	
3/20/79	70.2	6.9	7.15	11	23	120	165	3.07	5.16	
3/21/79	73.2									
3/22/79	74.4	7.15	7.32	11	21	71	86	3.34	3.68	
3/22/79		7.27	7.95	7	8	77	304	1.38	1.97	
3/23/79	87.2									
3/24/79	71.7	7.21	7.4	42	27	143	120	2.95	4.8	
3/25/79	63.3	7.51	7.44	20	26	172	214	2.75	1.99	
3/26/79	63.5									
3/27/79	64.7	7.47	7.73	27	46	145	231	1.66	2.73	
3/28/79	68.2									
3/29/79	101.1	7.25	7.3	32	20	202	260	2.84	3.28	

TABLE 3 (cont.)
(Ref.No.16

THREE MILE ISLAND NUCLEAR STATION
MONTHLY OPERATING REPORT
MAIN DISCHARGE
CHEMICAL DISCHARGES
MARCH 1979

Parameter	Volume	pH		TSS		TDS		Total FE		Oil & Grease
Units	10^6 Gal.	Standard Units		mg/l		mg/l		mg/l		mg/l
Sample Type	Meas.	Grab		Grab		Grab		Grab		Grab
Frequency	Daily	Weekly		Weekly		Weekly		Weekly		Weekly
Date	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Eff.
3/30/79	79.1									
3/31/79	106.6	6.95	7.1	32	43	110	149	1.71	2.23	

TABLE 4
(Ref.No.17)

THREE MILE ISLAND NUCLEAR STATION
MONTHLY OPERATING REPORT
MAIN DISCHARGE
CHEMICAL DISCHARGES
APRIL 1979

Parameter	Volume	pH		TSS		TDS		Total FE		Oil & Grease
Units	10^6 Gal.	Standard Units		mg/l		mg/l		mg/l		mg/l
Sample Type	Meas.	Grab		Grab		Grab		Grab		Grab
Frequency	Daily	Weekly		Weekly		Weekly		Weekly		Weekly
Date	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Eff.
April 1, 1979	94.7	7.1	7.2	24	24	130	154	1.45	2.53	
2,	85.3									
3,	85.4	7.64	7.65	1	7	127	148	1.68	2.08	
4,	82.2									
5,	86.0	7.16	7.3	32	39	214	187	0.96	1.23	
6,	84.6									
7,	81.5	7.48	7.69	9	25	166	143	1.85	1.9	
8,	83.3	7.19	7.38	18	44	83	133	2.07	2.55	
9,	91.2									
10,	80.6									
11,	75.9	7.49	7.61	1.0	7.0	159	181	1.26	2.12	
12,	84.7	7.54	7.59	46	64	281	132	1.02	1.13	
13,	79.3									
14,	79.7									
15,	78.1									
16,	84.2									
17,	79.3									
18,	80.0									
19,	83.0									
20,	75.3									
21,	94.0									
22,	61.3									
23,	75.0	7.06	7.37	2	4	117	124	0.58	0.94	
24,	83.5	7.05	7.2	9	19	150	190	1.39	1.77	
25,	70.2									
26,	82.6									
27,	77.3	7.14	7.72	15	15	149	159	0.85	0.97	
28,	78.2	7.05	7.85	36	15	315	335	1.98	1.52	
29,	77.6									
30,	84.0	7.83	7.67	8	26	151	167	1.15	2.16	

B. Chemical Discharges and River Flow

The Commonwealth of Pennsylvania NPDES Permit requires monitoring of several chemical parameters at various monitoring points and discharge locations within Three Mile Island Nuclear Station. One of the monitoring points is in the main effluent discharge to the river (monitoring point No. 001) and another is in the discharge from the industrial waste treatment system (IWTS; monitoring point No. 107) prior to its entry into the effluent discharged through the main river effluent discharge. Results of such monitoring are reported to the Commonwealth in monthly Discharge Monitoring Reports (DMR). Results of monitoring at those two points were reported in the DMR's for March 16/ and April 17/ 1979 and are presented here in Tables 3, 4, 5, and 6. Additionally, data collected by the Pennsylvania Department of Environmental Resources 21/ on April 13 and April 30, 1979 were made available to NRC and are presented in Table 7. Data collected in the Susquehanna River under the ETS program during March 22/ 23/ and April 23/ 24/ 1979 by Ichthyological Associates, Inc (consultant to Metropolitan Edison Co.) are presented in Tables 8 and 9, with their locations described in Table 10 and shown in Figure 2.

During about the first two weeks following the accident, several NRC Office of Inspection and Enforcement (OIE) Preliminary Notification bulletins reported releases of industrial wastes into the river. On March 29 less than 50,000 gallons were released 26a/ and between March 30

and April 3 controlled releases of "several hundred thousand gallons" occurred [26b]. Discharge to the river from the industrial waste storage tanks resumed on April 6 at an average rate of 100 gpm (~0.22 CFS)[26c] and was stopped late on April 7 [26d]. All totalled, between March 28 and April 11, 1979, 4,580,000 gallons were released from the IWTS and 760,000 gallons were released form the industrial waste filter system (IWFS, monitoring point No. 104)[27]. Total releases during the period March 28-May 19, 1979 from the IWTS, IWFS, waste evaporator condensate storage tank (WECST), and the secondary neutralization tank (SNT, monitoring point No. 108) were as follows, based upon information supplied to OIE from Metropolitan Edison Company [28]:

System	Total Releases in gallons	Mean Vol. per Release in gallons	Mean Vol. Release per day in gallons	Mean Vol. Release in gpm (CFS)
IWTS	4,993,660	222,890	96,032	66.7(0.15)
IWFS	962,830	57,743	17,362	12.1(0.03)
WECST	164,659	4,191	3,117	2.2(<0.01)
SNT	1,310,341	63,701	25,199	17.5(0.04)

The NPDES Permit places limits on discharges from the IWTS, IWFS, and the SNT. During the several weeks following the March 28 accident, no

violations of NPDES water quality limitations were recorded on days when samples were taken at the IWTS monitoring point (Tables 5, 6, and 7), in the main discharge effluent (Tables 3, 4, and 7), and in the river near and downstream of the discharge (Table 8). The noncompliance noted on Table 5 during March occurred on March 7, 1979 and was reportedly due to equipment failure [29]. No chlorine usage occurred during either March or April 1979 [16] [17]. No noncompliances or limit violations were reported for the IWFS during March following the accident. No samples were collected in April at the IWFS monitoring point, but discharges from the system are released through the main river discharge where no violations occurred.

Before discharge into the river, the IWTS and IWFS effluents are diluted with the cooling tower blowdown. A comparison of total volumes and the mean volumes of releases (shown above) with the daily effluent volumes at the main discharge to the river (Tables 3 and 4), illustrates the relatively small quantities of industrial-type wastes released. The volumes released during March and April were not unusual volumes or significantly different from those released during normal operation [27] [28] [30]. Additionally, all of the station effluent was diluted with the flows of the Susquehanna River which were seasonally high during the period, as discussed below. Dilution by itself, however, is not the means to environmentally acceptable station operation, although dilution can result in reducing potentially harmful or toxic concentrations of discharge substances to non-harmful concentration

levels. During the period of concern here, however, toxic concentrations of non-radiological effluents do not appear to have been released into the river and violations of water quality limitations did not occur. Water quality parameters measured in the discharge and both near and downstream of the discharge (Tables 7, 8, and 9) were not substantially different overall from ambient levels at upstream river areas and near the cooling water intake structures, located ∿750-1000 feet (∿229-305m) upstream of the discharge (Tables 3, 4, 7, 8, and 9).

Since October 1890, the U. S. Geological Survey (USGS), Department of the Interior, has been recording discharge flow in the Susquehanna River at Harrisburg, Pennsylvania. During the period of record between 1890 and 1977, the average annual discharge has been 34,300 CFS (∿22,192 MGD). The maximum and minimum daily discharges of record are 1,020,000 CFS (during Tropical Storm Agnes in June 1972) and 1,700 CFS respectively 34/. The river flows for the months of March-May during 1976-1979 are presented in Table 11. The 1979 data are considered to be provisional data by USGS, and not final computations. The provisional daily flows for the months of March and April 1979 are presented in Table 12. During the period of the accident at Three Mile Island, the river flows were above the annual mean flow and within the ranges recorded for the last several years.

During low flow conditions of 1,700 CFS, approximately 400 CFS (∿24%) of the river discharge passes Three Mile Island in the center channel, with

the remainder passing through the west channel (Figure 2) [37]. At flow rates below about 20,000 CFS, the total river flow passes through the head race channel of York Haven Dam leading to the hydroelectric generating station, with no flow over either York Haven Dam or Red Hill Dam (Figure 2) [38]. During high flow conditions, approximately 30% of the river flow is through the center channel. During the period March 28 through the end of April 1979, the minimum and maximum daily river flows were 31,400 CFS and 99,700 CFS respectively (Table 12). Assuming a minimum of 30% of the flow was through the center channel, a minimum range of 9,420 - 29,910 CFS would have passed the nuclear station and received discharge effluents before mixing with the remainder of the river flow near and below York Haven Dam.

The spatial extent or size of the discharge plume has not been determined for chemical effluents, but it has been determined for thermal effluents during normal operations and during normal cooldown conditions on several occasions in recent years. Thermal plume mapping is a required monitoring program in the Environmental Technical Specifications. During years of Unit 1 operation only, the following thermal plume conditions were recorded:

1974 [11] - plume characteristics were distinguished less than 20m (66 ft) into the river and 50m (164 ft) downstream of the discharge; generally thermal characteristics were maintained throughout the water column (0-3m); the farthest downstream distance that the plume was located was 400m (1312 ft).

1975 [12] -in 20 of 28 surveys the plume was limited to the point of discharge; the maximum extent of the plume was defined to be within at least 5m (16 ft) offshore and 100m (328 ft) downstream.

1976 [13]- in 28 of 33 surveys the plume was limited to 5m offshore and 25m (82 ft) downstream; the maximum extent of the plume during the February 21 cooldown was 5-20m offshore and 1000m (3281 ft) downstream.

1977 [14]- during the March 19-20 cooldown, the plume was limited to the point of discharge.

During 1978, the plume was surveyed during May - August when Unit 1 was operating at 100% power and Unit 2 was operating 0% power (although it had attained criticality in March and was operating nuclear and secondary service pumps during the period of plume surveys). During all surveys (from the discharge, offshore to 40m and downstream to 1900 m, or about 1.2 miles) the thermal effluent was confined to within 5m of shore and 25m downstream [15].

These observations indicate that the thermal plume has been variable in downstream extent (0-1000m, or to about 0.6 mile), has been confined to within short distances of the shoreline (0-20m), and to depths of about 3m in the center channel of the Susquehanna River, which is approximately 1300 feet (~400m) wide and 9 feet (~2.7m) deep at low flows of about 10,000 cfs [33]. Using these criteria and recognizing that the chemical

discharges follow a similar path as the thermal effluent, that portion of the river potentially under the immediate influence of chemical effluents could be presumed to be the same as for the thermal plume. That area (< 20m wide and 1000m long) would occupy the west shore of Three Mile Island from the station discharge downstream to a point about halfway between the discharge and the junction of Three Mile Island and the York Haven Dam (Figure 2). That area is a relatively small portion of both the center channel and the river as a whole in the site vicinity. Chemical substances discharged into the river, however, might be found in detectable amounts farther downstream of the area where thermal effluents were no longer detectable.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
DISCHARGE MONITORING REPORT

Form Approved
OMB NO: 158-R0011

Metropolitan-Edison Company (July 1, 1977 to expiration)
Three Mile Island Nuclear Generating Station

IWTS Monitoring Point, March 1979

TABLE 5
(Ref.No.16)

PA | 0009920 (PERMIT NUMBER) | 107 (DIS) | 4911 (SIC) | 40° 9'10" (LATITUDE) | 76° 43'35" (LONGITUDE)

REPORTING PERIOD FROM 79 03 01 (YEAR MO DAY) TO 79 03 31 (YEAR MO DAY)

INSTRUCTIONS

1. Provide dates for period covered by this report in spaces marked "REPORTING PERIOD".
2. Enter reported minimum, average and maximum values under "QUANTITY" and "CONCENTRATION" in the units specified for each parameter as appropriate. Do not enter values in boxes containing asterisks. "AVERAGE" is average computed over actual time discharge is operating. "MAXIMUM" and "MINIMUM" are extreme values observed during the reporting period.
3. Specify the number of analyzed samples that exceed the maximum (and/or minimum as appropriate) permit conditions in the columns labeled "No. Ex." If none, enter "0".
4. Specify frequency of analysis for each parameter as No. analyses/No. days. (e.g., "3/7" is equivalent to 3 analyses performed every 7 days.) If continuous enter "CONT."
5. Specify sample type ("grab" or "__ hr. composite") as applicable. If frequency was continuous, enter "NA".
6. Appropriate signature is required on bottom of this form.

PARAMETER		QUANTITY (if used only) MINIMUM	QUANTITY AVERAGE	QUANTITY MAXIMUM	QUANTITY UNITS	NO. EX	CONCENTRATION (if used only) MINIMUM	CONCENTRATION AVERAGE	CONCENTRATION MAXIMUM	CONCENTRATION UNITS	NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
Flow	REPORTED	.002	.078	.178	MGD	N/A	*****	*****	*****	N/A	N/A	cont.	measured
	PERMIT CONDITION	N/A	N/A	N/A			*****	*****	*****			2/30	measured
Total Suspended Solids	REPORTED	0.00	2.96	5.92	lbs/day	0	N/A	N/A	N/A	N/A	N/A	2/31	grab
	PERMIT CONDITION	N/A	36	240			N/A	N/A	N/A			2/30	grab
Oil & Grease	REPORTED	1.58	2.01	2.45	lbs/day	0	N/A	N/A	N/A	N/A	N/A	2/31	grab
	PERMIT CONDITION	N/A	18.1	48.1			N/A	N/A	N/A			2/30	grab
Total Iron	REPORTED	1.06	1.95	2.83	lbs/day	1*	N/A	N/A	N/A	N/A	N/A	2/31	grab
	PERMIT CONDITION	N/A	1.2	2.4			N/A	N/A	N/A			2/30	grab
Total Copper	REPORTED	0.02	0.02	0.02	lbs/day	0	N/A	N/A	N/A	N/A	N/A	2/31	grab
	PERMIT CONDITION	N/A	1.2	2.4			N/A	N/A	N/A			2/30	grab
pH	REPORTED					N/A	6.92	7.03	7.13	Std. pH Units	0	2/31	grab
	PERMIT CONDITION	N/A	N/A	N/A			6.0	N/A	9.0		0	2/30	grab
	REPORTED												
	PERMIT CONDITION												
	REPORTED												
	PERMIT CONDITION												

NAME OF PRINCIPAL EXECUTIVE OFFICER: Herbein (LAST) John (FIRST) G. (MI)
TITLE OF THE OFFICER: Vice-President (TITLE)
DATE: 79 (YEAR) 04 (MO) 27 (DAY)

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

SIGNATURE OF ~~PRINCIPAL EXECUTIVE OFFICER~~ AUTHORIZED AGENT

T-40 (4-74)

ORIGINAL

* Reported in Noncompliance Notification 79-02

DISCHARGE MONITORING REPORT

Form Approved
OMB NO. 158-R0019

Metropolitan-Edison Company (July 1, 1977 to expiration)
Three Mile Island Nuclear Generating Station

IWTS Monitoring Point, April 1979

TABLE 6
(Ref.No.17)

INSTRUCTIONS

1. Provide dates for period covered by this report in spaces marked "REPORTING PERIOD".
2. Enter reported minimum, average and maximum values under "QUANTITY" and "CONCENTRATION" in the units specified for each parameter as appropriate. Do not enter values in boxes containing asterisks. "AVERAGE" is average computed over actual time discharge is operating. "MAXIMUM" and "MINIMUM" are extreme values observed during the reporting period.
3. Specify the number of analyzed samples that exceed the maximum (and/or minimum as appropriate) permit conditions in the columns labeled "No. Ex." If none, enter "0".
4. Specify frequency of analysis for each parameter as No. analyses/No. days. (e.g., "3/7" is equivalent to 3 analyses performed every 7 days.) If continuous enter "CONT."
5. Specify sample type ("grab" or "___ hr. composite") as applicable. If frequency was continuous, enter "NA".
6. Appropriate signature is required on bottom of this form.

ST	PERMIT NUMBER	DIS	SIC	LATITUDE	LONGITUDE
PA	0009920	107	4911	40° 9'10"	76° 43'35"

REPORTING PERIOD FROM YEAR 79 MO 04 DAY 01 TO YEAR 79 MO 04 DAY 30

PARAMETER		QUANTITY (if used only) MINIMUM	QUANTITY AVERAGE	QUANTITY MAXIMUM	UNITS	NO. EX	CONCENTRATION (if used only) MINIMUM	CONCENTRATION AVERAGE	CONCENTRATION MAXIMUM	UNITS	NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
Flow	REPORTED	0	0.080	0.243	MGD	N/A	*****	*****	*****	N/A	N/A	cont.	measured
	PERMIT CONDITION	N/A	N/A	N/A			*****	*****	*****			2/30	measured
Total Suspended Solids	REPORTED	0.75	7.53	14.3	lbs/day	N/A	N/A	N/A	N/A	N/A	N/A	2/30	grab
	PERMIT CONDITION	N/A	36	240			N/A	N/A	N/A			2/30	grab
Oil & Grease	REPORTED	4.7	8.6	12.5	lbs/day	N/A	N/A	N/A	N/A	N/A	N/A	2/30	grab
	PERMIT CONDITION	N/A	18.1	48.1			N/A	N/A	N/A			2/30	grab
Total Iron	REPORTED	0.22	0.39	0.56	lbs/day	N/A	N/A	N/A	N/A	N/A	N/A	2/30	grab
	PERMIT CONDITION	N/A	1.2	2.4			N/A	N/A	N/A			2/30	grab
Total Copper	REPORTED	0.018	0.02	0.022	lbs/day	0	N/A	N/A	N/A	N/A	N/A	2/30	grab
	PERMIT CONDITION	N/A	1.2	2.4			N/A	N/A	N/A			2/30	grab
pH	REPORTED					N/A	7.3	7.33	7.35	Std. pH Units	0	2/30	grab
	PERMIT CONDITION	N/A	N/A	N/A			6.0	N/A	9.0		0	2/30	grab
	REPORTED												
	PERMIT CONDITION												
	REPORTED												
	PERMIT CONDITION												

NAME OF PRINCIPAL EXECUTIVE OFFICER	TITLE OF THE OFFICER	DATE
Herbein John G.	Vice-President	79 05 25
LAST FIRST MI	TITLE	YEAR MO DAY

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

SIGNATURE OF ~~PRINCIPAL EXECUTIVE~~ OFFICER OR AUTHORIZED AGENT

EPA Form 3320-1 (4-74)

ORIGINAL

Table 7. Water Quality Data Compiled by the Pennsylvania Department of Environmental Resources for Three Locations at Three Mile Island Nuclear Station During April of 1979. (Ref. No. 21).

	April 13			April 30
Parameter	River Intake	Main Discharge(001)	IWTS (107)	Main Discharge (001)
pH	7.6	7.1	6.5	7.8
Total Sulfate, mg/l	30.0	32.0	76.0	-
Total Alkalinity as $CaCo_3$,mg/l	30.0	32.0	18.0	44.0
Total Nitrate, mg/l	1.32	1.42	8.8	-
Total Nitrite, mg/l	0.028	0.028	0.024	-
Total Ammonia Nitrogen, mg/l	0.32	0.49	0.55	-
Total Phosphate, mg/l	0.22	0.22	0.66	0.08
Total Iron, ug/l	1930.0	1960.0	1160.0	1110.0
Chloride, mg/l	10.0	12.0	33.0	-
5-Day BOD, mg/l	0.4	0.5	18.0	-
Specific Conductance	150.0	160.0	310.0	-

Table 8 (Ref.Nos.22 and 23)

Summary of selected physicochemical parameters taken on 19 and 26 March 1979 near the TMINS. Values are expressed in mg/l except for water temperature (C), pH, and turbidity (JTU).

Location	Date	Water Temperature (C)	pH	Dissolved Oxygen	Turbidity (JTU)	Alkalinity as $CaCO_3$	Sulfate	Total Dissolved Solids	Total Copper	Dissolved Copper	Total Zinc	Dissolved Zinc
TM-AQI-1A1	19 Mar	5.0	-	11.6	23	27	37	111	0.009	0.003	0.031	0.019
TM-AQI-1A2		5.0	-	11.6	23	27	35	101	0.010	0.003	0.032	0.018
TM-AQI-11A1		5.5	-	11.5	24	27	37	107	0.010	0.003	0.032	0.016
TM-AQI-11A2		6.5	-	11.4	24	27	35	110	0.010	0.003	0.032	0.019
TM-AQI-9B1		6.0	-	11.5	23	27	33	106	0.012	0.003	0.031	0.017
TM-AQI-1A1	26 Mar	6.0	-	9.2	18	37	45	126	0.010	0.010	0.033	0.009
TM-AQI-1A2		7.0	-	10.0	16	38	41	119	0.010	0.010	0.024	0.006
TM-AQI-11A1		7.5	-	9.6	18	39	45	123	0.010	0.010	0.024	0.005
TM-AQI-11A2		7.5	-	9.7	16	39	44	120	0.010	0.010	0.025	0.006
TM-AQI-9B1		7.0	-	9.2	17	38	38	119	0.010	0.010	0.024	0.005
						MEAN VALUES FOR MARCH 1979						
TM-AQI-1A1	Mar	5.5	-	10.4	20	32	41	118	0.010	0.006	0.032	0.014
TM-AQI-1A2		6.0	-	10.8	20	32	38	110	0.010	0.006	0.028	0.012
TM-AQI-11A1		6.5	-	10.6	21	33	41	115	0.006	0.006	0.028	0.010
TM-AQI-11A2		7.0	-	10.6	20	33	40	115	0.010	0.006	0.028	0.012
TM-AQI-9B1		6.5	-	10.4	20	32	36	112	0.011	0.006	0.028	0.011

Table 9 (Ref. Nos. 23 and 24)

Summary of selected physicochemical parameters taken on 11 and 23 April 1979 near the TMINS. Values are expressed in mg/l except for water temperature (C), pH, and turbidity (JTU).

Location	Date	Water Temperature (C)	pH	Dissolved Oxygen	Turbidity (JTU)	Alkalinity as $CaCO_3$	Sulfate	Total Dissolved Solids	Total Copper	Dissolved Copper	Total Zinc	Dissolved Zinc
TM-AQI-1A1	11 Apr	7.5	7.5	11.3	10	31	45	118	0.010	0.010	0.028	0.018
TM-AQI-1A2		7.5	7.6	11.2	10	33	42	116	0.010	0.010	0.021	0.010
TM-AQI-11A1		7.5	7.5	11.6	10	33	45	117	0.010	0.010	0.022	0.010
TM-AQI-11A2		7.5	7.5	11.0	9	33	44	116	0.010	0.010	0.022	0.011
TM-AQI-9B1		8.0	7.5	11.2	10	32	40	119	0.010	0.010	0.022	0.013
TM-AQI-1A1	23 Apr	14.0	7.8	11.1	3.9*	25	38	114	0.003	0.002	0.021	0.005
TM-AQI-1A2		14.0	7.8	11.2	3.3*	30	41	121	0.003	0.002	0.018	0.002
TM-AQI-11A1		14.5	7.9	11.8	3.9*	30	47	122	0.002	0.002	0.019	0.003
TM-AQI-11A2		14.0	7.8	10.8	4.2*	30	45	142	0.002	0.002	0.016	0.006
TM-AQI-9B1		14.5	7.8	11.2	3.5*	30	47	132	0.002	0.002	0.014	0.002
						MEAN VALUES FOR APRIL 1979						
TM-AQI-1A1	Apr	10.8	-	11.2	7.0*	28	42	116	0.006	0.006	0.024	0.012
TM-AQI-1A2		10.8	-	11.2	6.6*	32	42	118	0.006	0.006	0.020	0.006
TM-AQI-11A1		11.0	-	11.7	7.0*	32	46	120	0.006	0.006	0.020	0.006
TM-AQI-11A2		10.8	-	10.9	6.6*	32	44	129	0.006	0.006	0.019	0.008
TM-AQI-9B1		11.2	-	11.2	6.8*	31	44	126	0.006	0.006	0.018	0.008

* Turbidity in NTU.

Station locations correspond to those in Figure 2 and Table 10.

TABLE 10
LOCATION AND DESCRIPTION OF WATER QUALITY AND MACROINVERTEBRATE SAMPLING STATIONS IN THE SUSQUEHANNA RIVER NEAR THREE MILE ISLAND NUCLEAR STATION. (Ref.No.14).

Station Number	Location and Description
TM-AQI-1A1 (No.1)	40° 09' 52" N, 76° 43' 26" W. North tip of Sand Beach Island, 30 to 75 m offshore. Water depth varied from 0.5 to 2.5 m. Substrate ranged from very coarse to medium sand. Coarse organic detritus was sometimes present.
TM-AQI-1A2 (No.2)	40° 09' 36" N, 76° 43' 30" W. Southwest St. Johns Island at mouth of channel between TMI and St. Johns Island, 1 to 15 m offshore. Water depth varied from 0.5 to 3.5 m. Substrate sometimes stratified ranging from silt and clay to gravel. In the absence of stratification most substrate composed of silt and clay and fine sands. Organic detritus and trace amounts of oil present.
TM-AQI-11A1 (No.3)	40° 09' 09" N, 76° 43' 39" W. West shore of TMI, 10 to 25 m downstream from Discharge, 1 to 15 m offshore. Water depth ranged from 0.25 to 2.0 m. Substrate composed mostly of silt and clay and fine sands. Organic detritus and trace amounts of oil present.
TM-AQI-11A2 (No.4)	40° 09' 07" N, 76° 43' 39" W. West shore of TMI, 75 to 90 m downstream from Discharge, 1 to 15 m offshore. Water depth varied from 0.25 to 2.0 m. Substrate composed of fine sands and silt and clay. Some organic detritus and trace amounts of oil present.
TM-AQI-9B1 (No.5)	40° 08' 03" N, 76° 43' 33" W. West shore of TMI, 1975 m downstream from Discharge, 5 to 15 m offshore. Water depth varied from 0.75 to 2.25 m. Substrate composed of silt and clay and fine sands. Some organic detritus and trace amounts of oil present.

Table 11. Water Discharge (cfs) in the Susquehanna River at Harrisburg, Pennsylvania during March, April, and May for the years 1976-1979, from USGS records. Data for 1979 are considered to be provisional and not final computations

	1976[35/]	1977[34/]	1978[36/]	1979[36/]
March				
mean	57,550	115,400	97,330	124,000
max.	114,000	206,000	249,000	409,000
min.	34,100	68,500	14,000	48,000
April				
mean	37,630	77,010	82,620	55,869
max.	82,200	209,000	162,000	84,700
min.	20,100	24,200	32,400	31,400
May				
mean	30,930	26,540	72,950	39,000
max.	50,800	44,400	205,000	91,600
min.	19,300	13,300	24,500	18,500

TABLE 12. Daily Water Discharge (cfs) in the Susquehanna River at Harrisburg, Pennsylvania during March and April 1979. Data are considered provisional by USGS. [36/]

Day	March	April
1	105,000	54,300
2	90,800	55,100
3	90,200	55,600
4	90,200	57,800
5	126,000	64,400
6	317,000	68,800
7	409,000	64,700
8	347,000	59,200
9	270,000	54,200
10	217,000	53,500
11	177,000	68,000
12	154,000	84,700
13	133,000	83,200
14	107,000	77,300
15	93,300	72,900
16	87,600	69,000
17	83,100	66,800
18	73,500	63,100
19	62,900	58,400
20	55,500	53,300

TABLE 12. Cont'd. Daily Water Discharge (cfs) in the Susquehanna River at Harrisburg, Pennsylvania during March and April 1979. Data are considered provisional by USGS. [36/]

Day	March	April
21	52,000	47,100
22	49,800	42,700
23	48,000	39,100
24	48,500	36,100
25	55,700	33,700
26	86,300	31,600
27	105,000	*
28	99,700	31,400
29	84,600	35,800
30	68,300	38,400
31	57,000	—

* No data reported.

III. AQUATIC BIOTA AND FISHERIES OF THE SUSQUEHANNA RIVER, AND NON-RADIOLOGICAL CONSEQUENCES OF THE ACCIDENT

During the period 1974-1978, the aquatic biota of the York Haven Pond of the Susquehanna River were studied in considerable detail with respect to the operation of Three Mile Island Nuclear Station 11/ 12/ 13/ 14/ 15/ 39/ 40/ 57/. Data collected in 1979 for the periods before, during, and following the accident were available in summary form in monthly progress reports prepared by Licensee's consultant Ichthyological Associates, Inc. As such, the 1979 data are not as detailed or as fully analyzed statistically as those data contained in the annual reports of aquatic studies. However, the 1979 progress reports are a form of summarized data available soon after collection (~ one month) and are used here to examine the biotic conditions of the river during the period of interest.

The Environmental Technical Specifications (ETS) for Unit 2 were issued by NRC on February 8, 1978 and require three years of operational studies for macrobenthos, ichthyoplankton, fishes, creel surveys, ichthyoplankton entrainment and fish impingement. Additionally, the ETS require the Licensee to make a prompt report to NRC of any unusual or important events such as fish kills near or downstream of the site. The initial studies of two-unit operation are contained in the annual report for 1978. 15/ The Commonwealth of Pennsylvania NPDES Permit requires the in-plant monitoring of thermal and chemical effluents and entrainment and impingement, but not farfield biological, fisheries, and water quality studies in the Susquehanna River. The

combination of the results of the effluent monitoring under the NPDES Permit and the farfield monitoring required by the ETS thus encompass the spectrum of data needed to perform an analysis of observed effects of the nuclear accident at Three Mile Island Nuclear Station.

A. Macroinvertebrates

Macroinvertebrates are collected by Ponar grab at five stations upstream, near, and downstream of the effluent discharge (Figure 2; Table 10), March through December. Substrates at the various stations ranged from medium - coarse sand (91%) at upstream station 1 to fine sand (25%) and silt (71%) at the station (No. 5) nearest to York Haven Dam [15]. Substrates at stations nearest the discharge were predominantly fine sand, silt and clay. Studies in the immediate vicinity of the discharge have revealed no obvious area of scouring of the river bed due to discharges [38].

During 1978, 142 taxa of macroinvertebrates were collected from the river, with the dominant species being tubificid annelid worms (*Limnodrilus* spp), chironomid (midge) insects (*Chironomus* sp, *Procladius* spp), amphipod crustaceans (*Gammarus*, sp), and gastropod molluscs (*Goniobasis* sp) [15]. *Limnodrilus* generally has been the most abundant macroinvertebrate in the site vicinity during recent years and has been most abundant at station 3 nearest the discharge and least abundant at station 1 upstream [15]. Densities of this species and other dominant

organisms generally have been low during early spring months and increased to peaks during late spring through fall. Densities and biomass of most benthic invertebrates have been greatly affected by ambient environmental variables such as river flow, substrates, dissolved oxygen, temperature, and siltation [15]. Extreme conditions during the flooding and scouring caused by Hurricane Eloise in September 1975 drastically affected the macrobenthos of the river near Three Mile Island [8] [12].

During 1979, macrobenthos were not collected during January and February due to ice and high river flows [41] [42]. During March, sampling was conducted on the 19th nd 26th of the month [22] and during April on the 11th and 23rd [23], but data reduction had not been completed for presentation in the appropriate monthly reports. At the request of NRC, the Licensee's consultant prepared tabular estimates of the densities and biomass of selected macroinvertebrate taxa at all stations for the months of March-May 1979, which are presented here as Tables 13 and 14 [43]. The patterns of abundance in 1979 generally follow those of recent years. Chironomus was considerably greater in density at all stations during 1979 than during either 1977 [14] or 1978 [43].

Stations discharges were within specified limitations and did not alter the environmental conditions of the river with respect to water quality and temperature. Discharges were within previously evaluated ranges which were found to be acceptable. The Unit 2 ETS bases for the benthic

macroinvertebrate monitoring program recognize that "Since benthic organisms are sedentary and cannot 'avoid' adverse conditions, they are useful indicators of water quality and environmental change." The data available for the period encompassing the accident indicate that the dominate macroinvertebrate species were not affected by station operating conditions. The normal trend of generally increasing abundance with time from March through May indicates an absence of station-related effects from the accident.

TABLE 13
(Ref.No.43)

Estimates of density (number/m^2) of selected taxa, March through May 1979. Dashes indicate species not present.

	March	April	May
TM-AQI-1A1 (No.1)			
Limnodrilus claparedeianus	33	42	12
L. hoffmeisteri	156	385	324
L. udekemianus	-	-	-
Gammarus fasciatus	7	5	21
Chironomus decorus	26	31	3783
TM-AQI-1A2 (No.2)			
Limnodrilus claparedeianus	90	31	-
L. hoffmeisteri	593	896	1420
L. udekemianus	9	45	12
Gammarus fasciatus	147	21	80
Chironomus decorus	711	276	3906
TM-AQI-11A1 (No.3)			
Limnodrilus claparedeianus	128	165	54
L. hoffmeisteri	1654	1822	3686
L. udekemianus	-	24	147
Gammarus fasciatus	116	45	354
Chironomus decorus	347	260	7389
TM-AQI-11A2 (No.4)			
Limnodrilus claparedeianus	149	95	24
L. hoffmeisteri	1297	1545	2859
L. udekemianus	92	69	161
Gammarus fasciatus	111	17	286
Chironomus decorus	276	428	2292
TM-AQI-9B1 (No.5)			
Limnodrilus claparedeianus	47	95	-
L. hoffmeisteri	3006	3095	1928
L. udekemianus	24	73	99
Gammarus fasciatus	19	2	137
Chironomus decorus	147	9	6661

TABLE 14
(Ref.No.43)

Estimates of biomass of selected taxa (by weight), March through May 1979. Dashes indicate species not present. Weight in mg.

	March	April	May
TM-AQI-1A1 (No.1)			
Limnodrilus hoffmeisteri	28.6	112.7	65.9
Gammarus fasciatus	20.3	19.4	1.7
Chironomus decorus	21.7	7.1	697.1
Goniobasis virginica	2360.6	6210.1	1899.3
TM-AQI-1A2 (No.2)			
Limnodrilus hoffmeisteri	184.6	296.3	371.7
Gammarus fasciatus	396.7	47.0	32.4
Chironomus decorus	649.1	277.9	1027.4
Goniobasis virginica	1373.4	4721.4	1813.1
TM-AQI-11A1 (No.3)			
Limnodrilus hoffmeisteri	480.4	887.8	1218.1
Gammarus fasciatus	264.9	59.1	105.6
Chironomus decorus	257.8	245.5	1687.6
Goniobasis virginica	-	190.9	1000.9
TM-AQI-11A2 (No.4)			
Limnodrilus hoffmeisteri	453.7	746.0	1342.4
Gammarus fasciatus	267.7	16.8	109.2
Chironomus decorus	229.4	327.0	358.2
Goniobasis virginica	-	570.4	2995.5
TM-AQI-9B1 (No.5)			
Limnodrilus hoffmeisteri	998.6	1391.0	888.9
Gammarus fasciatus	39.5	0.9	48.2
Chironomus decorus	126.7	-	1707.0
Goniobasis virginica	-	250.0	4192.1

B. Fishes

The fish community of York Haven Pond is sampled by means of trapnet, seine, electroshocker, and plankton net. Additionally, samples are collected at the two intake structures for ichthyoplankton entrainment and fish impingement. Fifty-six species of fishes have been recorded during studies conducted between 1974 and 1978 (Table 15) 15/.

Trapnetting is conducted for four twenty-four hour periods per month at four stations along the west shore of Three Mile Island. Two of the stations are located downstream of the discharge, one at 20m and the other at 200m, which could be potentially under the immediate influence of the effluent plume. The 20m station is reported to receive strong current and turbulence from the discharge 15/. A third station is located upstream near St. John's Island and a fourth station is located 1900m downstream of the discharge. During 1977 and 1978, 26 and 24 species respectively were collected by trapnet 14/ 15/. Catches were dominated by pumpkinseed, black crappie, white crappie, channel catfish, carp, rock bass, and quillback. Catches generally were low in the spring and increased to maxima during summer and fall. During the months of March and April 1975-1978, catches have not always shown an overwhelming dominance of a species, but generally the most abundant fishes have been channel catfish, rock bass, pumpkinseed, quillback, and spottail shiner. Catch differences (numbers, species composition) among stations during March and April have not been dramatic in most cases. Those instances

where obvious difference existed which involved the stations close to the discharge are summarized as follows:

1975 -

April 9-11: of 56 total specimens taken at four stations, 31 specimens were taken at the station nearest the discharge; 24 of 38 channel catfish were captured at the discharge station (20m station).

1976 -

March 15-17: of 21 total specimens captured at four stations, none were taken at the station nearest the discharge (20m) and only 1 specimen was taken at the 200m station.

March 29-31: of 21 total fish taken, none were taken at the 20m station.

April 13-15: of 31 total fish taken, 18 were at the 20m station; spottail shiner and channel catfish were taken only at the 20m station.

1977 -

March 9-11: 12 of 21 total specimens were taken at the 20m station; rock bass were taken only at the 20m station.

March 29-31: 5 of 6 total specimens were taken at the 20m station, 3 were channel catfish and one each of pumpkinseed and yellow perch.

Historically, then, March-April catches by trapnet have not shown dramatic differences among stations. When differences did occur, catches were sometimes much less at the discharge station suggesting a possible avoidance by fishes. When catches were greater at the discharge stations, channel catfish were often dominant.

During 1979, trapnetting was not conducted during January and February due to ice and high river flow [41] [42]. Sampling was conducted on March 20-22 [22] and captured 25 fishes of nine species. Walleye, channel catfish, rock bass, and white crappie were most abundant. Sampling during April (9-11 and 18-20) [23] resulted in the capture of 31 fishes of 10 species, with shorthead redhorse, channel catfish and walleye most numerous. No apparent patterns existed for species abundance or composition with respect to the discharge plume stations. Species taken at the stations 20m and 200m downstream of the discharge included white sucker, marginated madtom, rock bass, redbreast sunfish, smallmouth bass, walleye, northern hog sucker, shorthead redhorse, and spottail shiner. During the subsequent months, trapnet catches increased to 108 fishes of 10 species in May [24] with pumpkinseed, white crappie and rockbass dominating. In June [44] 116 fishes of 15 species were taken with rock bass, pumpkinseed, and black crappie most numerous. The most numerous

species at the plume stations were pumpkinseed and rock bass. Trapnet catches during 1979 did not show any aberrant patterns or trends compared with previous years' data. Catches were relatively low in March and April and increased through May and June.

Seining is conducted twice per month at ten stations throughout the site vicinity. Four stations are located on the west shore of Three Mile Island downstream of the discharge at distances of 150m, 1100m, 1500m, and 2000m (near the dam) [15]. Total seine catches from all stations have ranged from 6,574 fishes of 30 species in 1975 [12] to 51,297 fishes of 38 species in 1978 [15]. Catches have been dominated by spotfin shiner, spottail shiner, tessellated darter, white sucker, bluntnose minnow, channel catfish, and quillback. Generally, catches have been relatively low during March-May with yearly peaks in June. During the months of March and April, catches have been dominated by spotfin shiner, spottail shiner, and bluntnose minnow. On numerous occasions during 1975, 1976, and 1977 catches were noticably larger at the station 150m downstream of the discharge than at other stations on the west shore of Three Mile Island with spotfin shiner, spottail shiner, and bluntnose minnow dominating.

During 1979, seining was not conducted during January and February due to ice and high river flows [41] [42]. Sampling was conducted on March 16 and captured 946 fishes of 13 species, with spotfin shiner and bluntnose minnow dominating [22]. Only 104 of the 946 fishes were taken at the

stations on the west shore of Three Mile Island, with most fishes caught in the east channel and west channel of the river. Sampling in April (10th and 16th) captured 1111 fishes of 11 species, with spotfin shiner, spottail shiner, and bluntnose minnow dominating [23]. Only 29 of the 1111 fishes were taken at the stations on the west shore of Three Mile Island, with most fishes (806) caught in the east channel. Similar patterns of higher abundance in the east and/or west channels also occurred on several sampling dates during March and April of 1977 [14] and April of 1978 [15]. On April 10, 1979 only four fishes were taken downstream of the discharge, all at the 1100m station. On April 16 fishes were taken at all of the downstream stations except that at 1500m. Species taken at the stations 150m and 1100m downstream of the discharge included spotfin shiner, spottail shiner, rosyface shiner, comely shiner, tessellated darter, and blacknose dace. During the subsequent months, seine catches increased to 2199 fishes of 22 species in May, with spottail shiner, spotfin shiner, bluntnose minnow, and pumpkinseed most numerous [24]. Of the 2199 fishes collected in May, 346 fishes were taken at the station 150m downstream of the discharge, with spottail shiner, spotfin shiner, and bluntnose minnow the most abundant species. In June 22,834 fishes of 30 species were captured [44]. Juvenile white sucker dominated the catches (45% of total fish caught), along with spottail shiner, spotfin shiner, tessellated darter and fallfish at all stations. 4844 fishes were taken at the 150m downstream station during June. In general, the species composition and patterns of abundance in 1979 were similar to those of previous years. During early April 1979, few fishes

were taken downstream of the discharge, but by mid-April abundance began increasing and continued to do so through June.

Electrofishing is conducted twice per month at 12 stations throughout the site vicinity. Four stations are located on the west shore of Three Mile Island. One extends from the discharge to a point 500m downstream, another is sampled between 1500 and 2000m downstream from the discharge, and two stations are sampled upstream of the discharge [15]. Total catches were 7,054 fishes of 26 species in 1977 [14] and 7,522 fishes of 31 species in 1978 [15]. Overall, catches have been dominated by smallmouth bass, pumpkinseed, rock bass, redbreast sunfish, quillback, carp, and walleye. No consistent trends in overall abundance have been evident, but catches have often been highest during spring and fall. During the months of March and April, catches have been dominated by smallmouth bass, pumpkinseed, quillback, redbreast sunfish, carp, rock bass and walleye. No distinct patterns or trends of differing fish distributions have been apparent with respect to the discharge effluent.

During 1979, electrofishing was not conducted during January and February due to ice and high river flows [41] [42]. Sampling on March 19 and 20 captured 140 fishes of 13 species with carp, walleye, rock bass, and quillback dominating [22]. Sampling in April (10th-11th and 23rd-24th) captured 1022 fishes of 24 species, with shorthead redhorse, walleye, rock bass, quillback, smallmouth bass, and pumpkinseed dominating [23]. No differing patterns or trends in abundance or distributions were

evident for fishes near the discharge, although in the latter April sampling more specimens (128) were collected at the discharge station than at other stations sampled. Species taken during March and April 1979 at the station extending from the discharge downstream for 500m included walleye, shorthead redhorse, quillback, smallmouth bass, white sucker, rock bass, pumpkinseed, redbreast sunfish, carp, and bluegill. During the months following, catches decreased to 726 fishes of 17 species in May [24] and 596 fishes of 22 species in June [44], with rock bass, smallmouth bass, walleye, and quillback dominating. In general, the patterns of species composition, abundance, and distribution in 1979 were similar to previous years.

Ichthyoplankton is sampled via plankton net once per week at 14 stations throughout York Haven Pond. Four stations are located along the west shore of Three Mile Island, two upstream of the discharge, one 200m downstream of the discharge, and one 200m upstream of the York Haven Dam [15]. During 1976-1978, fish larvae have first appeared in samples in mid-to-late-April with peak densities occurring about one month after the first larvae were taken, generally late May to mid-June [15]. The most abundant species have been carp, spottail shiner, spotfin shiner, quillback, channel catfish, pumpkinseed/bluegill, tessellated darter, and banded darter. In 1977 and 1978 respectively, 30 and 32 total species were recorded from ichthyoplankton samples. Generally, the east and west channels yielded the highest densities of larvae. Carp, quillback, and

banded darter have been in relatively high abundance along the west shore of Three Mile Island.

During 1979, ichthyoplankton sampling began in April and was conducted on the 10th, 17th and 24th. Sampling was not undertaken during the first week of April due to the accident at the nuclear station [23]. No larvae were collected in 56 samples on April 10. One shield darter larva was collected during each of the samplings on April 17 and 24 [23]. Both larvae were collected in the west channel. During the months following, larval catches increased to a peak in mid-May (4,746 larvae taken on May 15-16) [24], with a secondary peak on June 5-6 [44]. Species taken included spottail shiner, quillback, white sucker, tessellated darter, banded darter, shield darter and walleye. Darters dominated during the sampling on May 1 and suckers on May 8 [24]. In general, patterns of icthyoplankton abundance in 1979 (April-June) were similar to previous years. Fish larvae were not captured in the center channel near the nuclear station during April 1979.

In summary, the overall patterns of the fish community in the vicinity of Three Mile Island Nuclear Station during 1979 (March-June) were similar to those of previous years. Levels of abundance and species composition during the months immediately following the March 28 nuclear accident were not noticably different from previous years and generally were on the increase throughout the spring months, as usual. Fish spawning produced peak larval abundances in May and June, per the normal pattern.

Sampling by several gear types in the immediate plume area documented the presence of many species, including rough (carp, suckers), forage (shiners, darters), and predator/sprot fishery (walleye, bass, sunfishes) species. An absence of significant immediate effects with respect to the nuclear accident is in keeping with the facts that the non-radiological aspects of station operating conditions during and following the accident did not deviate from those of normal operation.

TABLE 15
(Ref.No.15)

List of scientific and common names of fishes recorded from the Susquehanna River near TMINS.

Scientific Name	Common Name
Amiidae	**Bowfins**
Amia calva Linnaeus	Bowfin
Anguillidae	**Freshwater eels**
Anguilla rostrata (Lesueur)	American eel
Clupeidae	**Herrings**
Alosa aestivalis (Mitchill)	Blueback herring
Alosa pseudoharengus (Wilson)	Alewife
Alosa sapidissima (Wilson)	American shad
Dorosoma cepedianum (Lesueur)	Gizzard shad
Salmonidae	**Trouts**
Salmo gairdneri Richardson	Rainbow trout
Salmo trutta Linnaeus	Brown trout
Salvelinus fontinalis (Mitchill)	Brook trout
Esocidae	**Pikes**
Esox lucius Linnaeus	Northern pike
Esox masquinongy Mitchill	Muskellunge
Esox niger Lesueur	Chain pickerel
Cyprinidae	**Minnows and carps**
Campostoma anomalum (Rafinesque)	Stoneroller
Carassius auratus (Linnaeus)	Goldfish
Cyprinus carpio Linnaeus	Carp
Exoglossum maxillingua (Lesueur)	Cutlips minnow
Nocomis micropogon (Cope)	River chub
Notemigonus crysoleucas (Mitchill)	Golden shiner
Notropis amoenus (Abbott)	Comely shiner
Notropis cornutus (Mitchill)	Common shiner
Notropis hudsonius (Clinton)	Spottail shiner
Notropis procne (Cope)	Swallowtail shiner
Notropis rubellus (Agassiz)	Rosyface shiner
Notropis spilopterus (Cope)	Spotfin shiner
Notropis volucellus (Cope)	Mimic shiner
Pimephales notatus (Rafinesque)	Bluntnose minnow
Pimephales promelas Rafinesque	Fathead minnow
Rhinichthys atratulus (Hermann)	Blacknose dace
Rhinichthys cataractae (Valenciennes)	Longnose dace
Semotilus atromaculatus (Mitchill)	Creek chub
Semotilus corporalis (Mitchill)	Fallfish
Catostomidae	**Suckers**
Carpiodes cyprinus (Lesueur)	Quillback
Catostomus commersoni (Lacepede)	White sucker
Hypentelium nigricans (Lesueur)	Northern hog sucker
Moxostoma macrolepidotum (Lesueur)	Shorthead redhorse
Ictaluridae	**Freshwater catfishes**
Ictalurus catus (Linnaeus)	White catfish
Ictalurus natalis (Lesueur)	Yellow bullhead
Ictalurus nebulosus (Lesueur)	Brown bullhead
Ictalurus punctatus (Rafinesque)	Channel catfish
Noturus insignis (Richardson)	Margined madtom
Cyprinodontidae	**Killifishes**
Fundulus diaphanus (Lesueur)	Banded killifish
Percichthyidae	**Temperate Basses**
Morone saxatilis (Walbaum)	Striped bass
Centrarchidae	**Sunfishes**
Ambloplites rupestris (Rafinesque)	Rock bass
Lepomis auritus (Linnaeus)	Redbreast sunfish
Lepomis cyanellus Rafinesque	Green sunfish
Lepomis gibbosus (Linnaeus)	Pumpkinseed
Lepomis macrochirus Rafinesque	Bluegill
Micropterus dolomieui Lacepede	Smallmouth bass
Micropterus salmoides (Lacepede)	Largemouth bass
Pomoxis annularis Rafinesque	White crappie
Pomoxis nigromaculatus (Lesueur)	Black crappie
Percidae	**Perches**
Etheostoma olmstedi Storer	Tessellated darter
Etheostoma zonale (Cope)	Banded darter
Perca flavescens (Mitchill)	Yellow perch
Percina peltata (Stauffer)	Shield darter
Stizostedion vitreum vitreum (Mitchill)	Walleye

C. Fish Disease, Parasites, and Mortalities

Fish disease and mortality conditions in the Susquehanna River near Three Mile Island have been recognized and were reviewed with respect to the operation of the nuclear station [6/] [45/]. Mortalities during the spring are not unusual and may be related to several causes, natural and man made [45/]. Mortalities of approximately 200 and 300 fishes were observed during the springs of 1974 and 1975 respectively [6/], but were not attributable to operation of Three Mile Island Nuclear Station [45/].

During routine farfield sampling from 1975-1978, observations of diseased, parasitized and dead fishes were maintained and reported in the annual reports of ecological studies. These observations are summarized in Table 16 and include:

(1) Fish leeches - Myzobdella lugubris and Placobdella montifera.
(2) Parasitic copepods - Lernaea sp.
(3) Fish louse (branchiuran) - Argulus catostomi
(4) Blackspot disease - metacercariae of digenetic trematodes, unspeciated.
(5) Spiny - headed worm - acanthocephalan sp.
(6) Myxosporidian protoza - Thelohanellus sp. (as subdermal cysts).
(7) Nematodes - unspeciated (encysted).
(8) Abnormalities.
(9) Observations of dead fish encountered while sampling.

The occurrence of diseased or parasitized fishes usually has been low during spring, with increases to peaks during August-September, and decreases during October-December [14/] [15/]. Fishes found dead and floating in the water have occurred during the spring, April-June [14/] [15/]. During the four years of observations, no patterns of diseases, parasites, or mortalities have been noted with respect to the location of affected fishes and the nuclear station.

During farfield sampling in 1979 (March-June), parasitized fishes were observed and the data are summarized in Table 17. Generally, the patterns of parasite occurrence during the spring months of 1979 were similar to those of previous years, with blackspot, copepods, and leeches most common. Blackspot was the most common parasite noted in the spring of 1979 and was most prevalent on spotfin shiner and other shiners and minnows, as in previous years. During April and May of 1978, blackspot infections were described as "slight to moderate" and were most prevalent on spotfin shiner [15/]. Copepods of the genus Lernaea are non-specific parasites [46/], as evidenced by their infestation on several different species during 1976-1978 (Table 16). Lernaea is active only during warm seasons, with temperatures above 18°C favoring the organism, and the optima being 22°-30°C [46/]. Parasitic copepods were less prevalent in 1979 than previous years, which might be related to water temperature, since the favorable 18°C was not reached until late May 1979 [24/]. Studies in the North Branch of the Susquehanna River also have revealed the presence of fish parasites and seasonal occurrences similar to some

noted near Three Mile Island [47/] [48/]. During 1973, for example, approximately 85% of the fishes examined in the North Branch were infected with one or more of 40 species of parasites, including copepods (Lernaea), branchiurans (Argulus), leeches, nematodes, trematodes, and acanthocephalans [47/]. It was noted that most parasites did not produce notable pathogenic symptoms in fish [47/].

Dead fishes observed while sampling during the spring of 1979 included 29 fishes in May and 47 fishes in June, with smallmouth bass the most numerous (Table 17). No dead fishes were reported in April immediately following the nuclear accident [23/] and no unusual biological events or fish kills were observed by biologists while sampling on the river during early April [49/] [50/]. The numbers seen dead in May and June 1979 (total of 76) were less than observed during 1977 and 1978, but involved similar species (Table 16). These general findings were also confirmed by the Pennsylvania Fish Commission Waterway Patrolman who patrols southern Dauphin County and the Three Mile Island vicinity [53/]. The mortalities observed during the springs of 1974 and 1975 also included similar species - smallmouth bass, sunfishes, and channel catfish [45/]. Annual mortalities of fishes also have been noted in the Conowingo Peservoir of the Susquehanna River downstream of Three Mile Island [45/]. Most dead fishes have occurred there during May and June and have included channel catfish, carp, guillback, white catfish, brown bullhead, eel, bluegill, pumpkinseed, largemouth bass, white crappie, and walleye.

Parasite and mortality conditions of fishes were observed in the York Haven Pond near Three Mile Island during the period March-June 1979. The observed conditions do not appear to be unusual for that period and generally follow trends previously noted for the area. Conditions of parasitism and spring mortalities are not unique to York Haven Pond and have been observed in other areas of the Susquehanna River upstream and downstream of the Three Mile Island site vicinity. It therefore appears probable that station operating conditions during and following the accident did not contribute to unusual disease or mortality conditions of fishes in the site vicinity.

Table 16. Records of diseased, parasitized, and dead fishes observed during 1975-1978 in the Susquehanna River near Three Mile Island Nuclear Station.

Year	Disease or Mortality Condition	Species Involved (Nos & months, if recorded)
1975 [12]	Fish leech	Channel catfish, sunfishes, tessellated darter; common parasite.
	Copepods	Spottail shiner (23), bluntnose minnow (1), bluegill (1); August.
	Blackspot	Spottail shiner (1), spotfin shiner (1).
	Spiny - headed worm Fish louse	Tessellated darter (1); May. Redbreast sunfish (1), Common shiner (1); June.
1976 [13]	Fish leech	Tessellated darters; common parasite, August-October, Channel catfish (1).
	Copepods	Comely shiner, spottail shiner, spotfin shiner, bluntnose minnow, smallmouth bass, bluegill; (few specimens each).
	Blackspot	Creek chub (1).
1977 [14]	Fish leech	Channel catfish (2), rock bass (1), redbreast sunfish (1), tessellated darter (38)-May to September; spottail shiner (3)-Sept-Nov.; carp(1).
	Blackspot	Common shiner, spotfin shiner, blacknose dace, fallfish, quillback, (few specimens each).
	Copepods	Stoneroller, carp, spottail shiner, spotfin shiner, bluntnose minnow, fallfish, white sucker, shorthead redhorse, rock bass, redbreast sunfish, pumpkinseed, smallmouth bass, black crappie, tessellated darter.

Table 16 (Continued)

	Myxosporidian protozoa	Comely shiner, bluntnose minnow; Common in July.
	Dead Fish (153)	Smallmouth bass (105), shorthead redhorse (10), channel catfish (8), suckers (10), rock bass (5), blueback herring (6), carp (4), fallfish (3), pumpkinseed (1), redbreast sunfish (1); April and May.
1978 15/	Fish leech	White catfish, channel catfish, rock bass, redbreast sunfish, black crappie, spottail shiner, tessellated darter; (few specimens each).
	Copepods	Channel catfish, rock bass, white crappie, redbreast sunfish, pumpkinseed, black crappie.
	Nematode	Marginated madtom (1), December.
	Dead fish (190)	Smallmouth bass (148), Channel catfish (13), Suckers (17), Carp (3), rock bass (3), redbreast sunfish (2), bluegill (1), quillback (1), yellow bullhead (1), unidentified sunfish (1); most occurred in June.
	Blackspot	Spotfin shiner (54), April-May; bluntnose minnow, Oct-Dec.
	Myxosporidian protozoa	Bluntnose minnow, comely shiner.
	Spinal deformity	Smallmouth bass.
	Nematode	Smallmouth bass.

Table 17. Records of diseased, parasitized, and dead fishes observed during 1979 (March-June) in the Susquehanna River near Three Mile Island Nuclear Station.

Month	Disease or Mortality Condition	Species Involved (Numbers & gear type)
March[22/]	Nematode	Marginated madtom (2)-trapnet.
	Fish leech	Smallmouth bass (1)-trapnet.
April[23/]	Nematode	Tessellated darter (4).
	Black spot	Spotfin shiner (33), mimic shiner (2), bluntnose minnow (9), blacknose dace (6) - all taken by seine.
May[24/]	Blackspot	Common shiner (1), spotfin shiner (69), bluntnose minnow (14) - seine.
	Copepods	Quillback (1) - seine.
	Fin rot	Quillback (1), shorthead redhorse (1) - seine.
	Dead fish (29)	Smallmouth bass (16), channel catfish (6), shorthead redhorse (4), rock bass (1), carp (1), sunfish sp. (1) - only 2 specimens taken downstream of discharge.
June[44/ 55/]	Blackspot	Spotfin shiner (86), golden shiner (1), common shiner (1) - seine.
	Copepods	Redbreast sunfish (1) - trapnet.
		Spotfin shiner (3) - seine.
	Fish leech	Rock bass (1) - trapnet.
		Rock bass (1) - seine.
	Jaw deformity	Spotfin shiner (1) - seine.
	Dead fish (47)	Smallmouth bass (25), shorthead redhorse (8), carp (1), white sucker (2), northern hog sucker (3), unidentified suckers (2), channel catfish (3), rock bass (3).

D. Recreational Fisheries

The recreational fisheries of the Three Mile Island site vicinity have been studied since 1974 and reported in the Annual [11/] [12/] [13/] [14/] [15/] and Supplemental [39/] [40/] [57/] Reports to NRC. Between-year comparisons are summarized in the 1978 Annual Report [15/]. Creel surveys have been conducted on two weekends days and two weekdays per month in four areas: the general reservoir (including the waters of the east, center, and west channels from Fall and Hill Islands to the north to Bashore Island and the York Haven Dam to the south; Figure 2); the east dam; the York Haven Dam; and the York Haven Generating Station (hydroelectric) tailrace [15/].

The total estimates of recreational fishing in the site vicinity during 1977 and 1978 (January-December) were:

	Total Anglers	Total Fish caught	Total Fish kept(%)	Total Hours fished	CPUE (fish/hr)
1977 [14/]	7,791	12,089	5,341 (44.2%)	14,773	0.82
1978 [15/]	14,089	27,979	9,490 (33.9%)	27,992	1.00

The species caught in greatest numbers overall in 1977 and 1978 respectively were: smallmouth bass (32% and 42%); channel catfish (28% and 24%); walleye (10% and 11%); rock bass (10% and 9%); sunfishes (10% and 5%); carp (7% and 4%); and suckers (1% and 1%). The bulk of the

harvests in the general reservoir during 1977 and 1978 respectively were: smallmouth bass (44% and 61%); channel catfish (25% and 13%); sunfishes (15% and 14%); rock bass (15% and 9%); and others. Smallmouth bass, rock bass and sunfishes (predominantly bluegill, pumpkinseed and redbreast) have been caught in greater numbers in the reservoir than at either dam or the York Haven tailrace. Walleye and channel catfish have been taken in greater numbers at the tailrace than at other locations. The reservoir has accounted for approximately 36% and 31% of the fishes caught in the area during 1977 and 1978 respectively, for 29% and 40% of the total anglers, and for 29% and 44% of the total hours fished. A summary of the creel survey data for the reservoir during the period 1974-1978 is presented in Table 18 [15]. Overall during 1977 [14] and 1978 [15], smallmouth bass catches were greatest during May-June, rock bass during May, channel catfish during July, walleye during May, and sunfishes during June-July. Good fishing (by boat) apparently also occurs near the nuclear station discharge for channel catfish (many greater than 20 inches long), with catches of walleye and muskellunge also [53]. Fishing occurs there primarily at night and continues yearround except for winter months during ice conditions [53].

During 1979, creel surveys were conducted four times per month in January and February at the York Haven Generating Station only, due to ice and high river flows [41] [42] and during mid-March through July at all survey areas [22] [23] [24] [44] [55]. Following the Three Mile Island accident, surveys were conducted on April 16, 21, 26, and 29 [33]. Creel survey

results for March-July 1979 are summarized in Tables 19 and 20. During that four month period, 63-82% of the anglers interviewed resided in York and Dauphin Counties, Pennsylvania, and most reported that they ate some of their catches.

Fishing in the general reservoir following the accident showed some interesting contrasts. The number of anglers interviewed during April-July were within the range of numbers reported during previous years (Tables 18, 19), but the hours fished were greater in April than in previous years and in the high-normal range during May-July. The numbers of anglers who fished the reservoir compared with the total numbers for all fishing areas surveyed were the lowest on record for April and May 1979 and within the historical ranges during June and July (Table 24). The relative numbers of hours fished on the reservoir were within historical levels for all post-accident months. The catch-per-effort (fish caught per angler-hour) was low-to-low-normal during April-June and a record high during July. The percentages of fish caught in the reservoir which were kept (actual harvest) by the anglers were the lowest on record for each post-accident month (Figure 3). During April, no fish were kept, all were returned. This is contrasted with the historical proportion harvested (Table 21) which has been as high as 85.7% during April. The composition of the recreational catches and harvests during March-July 1979 in the reservoir was primarily smallmouth bass, sunfishes, rock bass, and channel catfish (Table 22), as per historical trends. The relative contributions of the general reservoir to the total catches and harvests at all four locations

in the Three Mile Island vicinity during 1974-1979 are presented in Table 23. During previous years (1974-1978) no consistent annual patterns or trends existed with respect to the percent contribution of the reservoir to the total area catches and harvests during the months of April-July (Table 23), although the 5-year mean values for each month showed a generally increasing trend from April-July (Figure 4). During 1979 the percent contributions of the reservoir catches were the lowest on record in April and increased to historical levels during May-July. The percent contribution of the reservoir harvests (fishes actually kept by anglers) were the lowest on record during the post-accident months of April-June 1979 and did not reach historical levels until July (Table 23).

These data suggest that immediately following the 1979 accident, anglers were fishing relatively less and keeping fewer fishes from the reservoir than during previous years. During subsequent months, anglers slowly and steadily returned to near normal activities in the reservoir. Even three months post-accident, however, the relative harvests from the reservoir were still lower than any during the previous five years, and four months post-accident the percentages harvested from the reservoir itself were the lowest in six years of sampling.

Fishing in other creel survey areas of the Three Mile Island vicinity apparently increased somewhat following the accident (Tables 19 and 20). The numbers of anglers and fish caught at each dam and the tailrace were higher in April 1979 than during any previous April since 1974.

Similarly, the hours fished and catches-per-effort were either record highs or high-normal levels for those areas during April 1979. Only at the tailrace area was the percent harvested in April at a record low. The number of anglers at the York Haven Dam and the tailrace during May also were record highs. During June the percents harvested were record lows for all four survey areas.

The differences between the catches and harvests for the post-accident months of 1979 and those of corresponding months for 1974 through 1978 (as shown in Figures 3 and 4) were tested for statistical significance by analysis of variance which did not detect any differences attributable to year, month, or year-by-month interaction. A high degree of variability existed within the monthly data, however, which could have masked any real significant differences. In an attempt to reduce or stabilize the variance, the analysis was re-run using square root transformed data, and again statistically significant differences were not detected. The variability of the data could be the result of truely variable phenomena of catch and harvest or the result of a creel survey program which did not sample frequently enough to reduce the data variability of truely less variable phenomena.

Even though statistically significant differences were not detected between fishery parameters of 1979 and previous years, it is apparent that the recreational fishery was different following the accident than during corresponding periods preceding the accident. Post-accident recreational fishing in the Three Mile Island vicinity apparently was most altered in the reservoir, which contains the Island and the nuclear station. Fishing was not curtailed, but rather appeared to partially shift emphasis from

the reservoir to other areas, especially near the York Haven Dam and in the hydrostation tailrace. Whether there was an actual shift in areas fished or merely an avoidance of the reservoir (anglers who normally fish there stayed home) is uncertain, but record increases during April in the numbers of anglers, fish caught, hours fished, and catches-per-effort at most of the other areas surveyed suggests that a shift occurred immediately following the accident. Anglers apparently were fishing relatively less in the reservoir and those who did fish there were returning greater proportions of their catches than during any corresponding time period in the previous five years.

Several factors could have contributed to the observed differences. If the sizes of some desirable fishes were smaller than normal during 1979, then harvests might have been lower than normal. Size data were not presented in the monthly reports, thus between year comparisons are not possible at this time. Weather conditions can influence angler activity, but during 1979 the weather conditions on creel survey days were not severe and do not appear to have been substantially different from previous years. High angler activity at the dams and tailrace during 1979 suggest that fishing was not restricted by weather. The noted differences in fishery catches and harvests were not the result of impacts to the fish populations from the accident, but rather appear to have been due to altered fisherman behavior following the accident. Such alterations probably were related to the fishermen's knowledge of the occurrence of the accident and to their awareness of the liquid releases of industrial wastes to the river from the various station systems, as discussed in previous sections. Since fishing patterns changed following the accident, some anglers apparently missed a portion of the spring fishing in the reservoir which provides good local fishing for species such as smallmouth bass, rock bass, and sunfishes. With time following the accident, the patterns of recreational fishing returned to normal or near-normal.

TABLE 18

MONTHLY SUMMARIES OF CREEL SURVEY DATA COLLECTED FROM THE GENERAL RESERVOIR DURING THE PERIOD 1974-1978. (Ref.No.15).

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total May-Dec	TOTAL
Anglers												
1978	NO SURVEY	34	90	234	111	170	147	80	28	1	861	895
1977	-	50	54	90	49	50	49	14	-	-	306	356
1976	18	45	124	188	122	148	71	4	5	NO SURVEY	662	725
1975	17	28	70	67	91	58	117	7	10	-	420	465
1974	NO SURVEY		113	124	143	115	83	141	14	-	733	733
Fish Caught												
1978	NO SURVEY	62	107	328	207	247	234	126	86	-	1335	1397
1977	-	38	151	118	107	176	81	14	-	-	647	685
1976	4	17	180	267	237	423	175	18	-	NO SURVEY	1300	1321
1975	1	28	74	105	139	113	299	6	1	-	737	766
1974	NO SURVEY		179	116	183	141	204	315	6	-	1144	1144
Fish Kept												
1978	NO SURVEY	18	34	107	88	66	115	59	50	-	519	537
1977	-	29	72	61	75	71	30	10	-	-	319	348
1976	3	1	77	94	70	114	42	8	-	NO SURVEY	405	409
1975	-	24	44	84	62	58	123	1	1	-	373	397
1974	NO SURVEY		89	75	88	50	57	160	6	-	525	525
Hours Fished												
1978	NO SURVEY	64.00	158.05	642.80	218.85	334.75	301.20	167.85	63.85	1.00	1888.35	1952.35
1977	-	62.33	116.91	183.25	117.16	132.75	72.75	16.50	-	-	639.32	701.65
1976	22.50	61.25	206.50	371.25	235.25	301.82	126.33	7.50	9.00	NO SURVEY	1257.65	1341.40
1975	16.00	51.50	63.75	118.00	171.00	160.25	269.75	8.25	12.50	-	803.50	871.00
1974	NO SURVEY		157.25	226.50	307.00	221.25	176.50	345.25	8.75	-	1442.50	1442.50
Catch/Effort (h)												
1978	NO SURVEY	0.97	0.68	0.51	0.95	0.74	0.78	0.75	1.35	-	0.71	0.72
1977	-	0.61	1.29	0.64	0.91	1.33	1.11	0.85	-	-	1.01	0.98
1976	0.18	0.28	0.87	0.72	1.01	1.40	1.38	2.40	-	NO SURVEY	1.03	0.98
1975	0.06	0.54	1.16	0.89	0.81	0.71	1.11	0.73	0.08	-	0.92	0.88
1974	NO SURVEY		1.14	0.51	0.60	0.64	1.16	0.91	0.69	-	0.79	0.79

Table 19. Creel survey data from the General Reservoir and East Dam areas of the Three Mile Island site vicinity during March-July 1979.

	General Reservoir				
	March [22/]	April [23/]	May [24/]	June [44/]	July [55/]
No. Anglers	2	45	106	158	138
Fish Caught	3	30	105	251	300
Fish kept(%)	3(100)	0(0)	24(22.9)	48(19.1)	86(28.7)
Hrs. Fished	1.50	78.20	176.95	370.35	229.40
c/f(fish/hr)	2.00	0.38	0.59	0.68	1.31

	East Dam				
	March [22/]	April [23/]	May [24/]	June [44/]	July [55/]
No. Anglers	20	72	75	50	28
Fish Caught	22	270	121	166	37
Fish kept(%)	0(0)	26(9.6)	22(18.2)	14(8.4)	3(8.1)
Hrs. Fished	43.35	85.40	83.75	89.55	36.90
c/f(fish/hr)	0.51	3.16	1.44	1.85	1.00

Table 20. Creel survey data from the York Haven Dam and York Haven Generating Station Tailrace areas of the Three Mile Island site vicinity during March-July 1979.

	York Haven Dam				
	March [22]	April [23]	May [24]	June [44]	July [55]
No. Anglers	0	22	54	57	20
Fish Caught	0	231	481	329	75
Fish kept(%)	-	10(4.3)	42(8.7)	43(13.1)	16(21.3)
Hrs. Fished	0	37.40	111.75	131.80	31.75
c/f(fish/hr)	-	6.18	4.30	2.50	2.36

	York Haven Generating Station				
	March [22]	April [23]	May [24]	June [44]	July [55]
No. Anglers	64	139	225	177	160
Fish Caught	39	258	335	259	191
Fish kept(%)	15(38.5)	66(25.6)	124(37.0)	72(27.8)	106(55.5)
Hrs. Fished	62.10	240.00	401.65	415.45	246.30
c/f(fish/hr)	0.63	1.08	0.83	0.62	0.78

Table 21. Percentage of the fishes caught that were kept (harvested) by anglers fishing in the Three Mile Island vicinity during the March-July period between 1974-1978. Data compiled from that summarized in Reference No. 15. GR=general reservoir; ED-east dam; YHD=York Haven Dam; YHGS=York Haven Generating Station Tailrace.

1974	March	April	May	June	July
GR	-	-	49.7	64.7	48.1
ED	-	-	21.4	28.6	54.1
YHD	-	-	48.6	26.7	46.6
YHGS	-	-	34.4	75.7	48.0
1975					
GR	0	85.7	59.5	80.0	44.6
ED	-	57.1	38.4	43.9	15.0
YHD	-	0	29.4	26.2	59.2
YHGS	50.0	66.7	52.0	57.4	76.0
1976					
GR	75.0	5.9	42.8	35.2	29.5
ED	100.	3.0	21.4	21.9	-
YHD	0	0	30.3	35.2	0
YHGS	90.0	56.2	45.5	35.0	31.2
1977					
GR	-	76.3	47.7	51.7	70.1
ED	0	11.9	1.4	62.5	42.9
YHD	-	-	6.1	75.8	34.6
YHGS	50.0	55.6	47.1	48.0	52.8
1978					
GR	-	29.0	31.8	32.6	42.5
ED	-	3.8	6.9	22.4	30.0
YHD	-	0	9.5	33.1	35.2
YHGS	0	49.2	29.6	64.5	53.2

Table 22. Composition of the recreational fishery catch and harvest in the General Reservoir of the Three Mile Island site during March-July 1979.

Species	March 22/		April 23/		May 24/		June 44/		July 55/	
	Caught	Kept	Caught	Kept	Caught	Kept	Caught	Kept	Caught	Kept
Carp	-	-	1	0	2	1	-	-	-	-
White catfish	-	-	-	-	-	-	1	1	-	-
Brown bullhead	1	1	-	-	-	-	-	-	-	-
Channel catfish	2	2	1	0	12	9	37	5	32	19
Catfish spp.	-	-	-	-	-	-	2	1	-	-
Rock bass	-	-	1	0	9	4	22	10	47	17
Bluegill	-	-	-	-	-	-	1	0	1	1
Pumpkinseed	-	-	-	-	7	5	1	1	-	-
Redbreast sunfish	-	-	-	-	8	2	-	-	5	3
Sunfish spp.	-	-	9	0	28	3	22	6	11	0
Smallmouth bass	-	-	18	0	39	0	160	23	202	45
Black crappie	-	-	-	-	-	-	1	0	-	-
Crappie spp.	-	-	-	-	-	-	3	0	-	-
Yellow perch	-	-	-	-	-	-	1	1	-	-
Fallfish	-	-	-	-	-	-	-	-	1	1
Walleye	-	-	-	-	-	-	-	-	1	0
Total	3	3	30	0	105	24	251	48	300	86

Table 23. Relative contribution (% by number) of the General Reservoir to the total recreational fishery catch and total harvest (numbers kept) from all areas surveyed in the Three Mile Island vicinity during the months of April-July 1974-1979. Data computed from the referenced cited.

	% of Total Caught				% of Total Harvest			
	April	May	June	July	April	May	June	July
1974[15]	-	26.3	24.3	38.4	-	34.8	31.1	38.1
1975[15]	30.1	14.3	25.6	35.9	32.4	18.3	36.4	27.0
1976[15]	7.7	34.4	31.1	57.0	2.3	38.3	33.5	56.9
1977[14]	15.2	42.2	40.1	37.8	24.0	58.1	38.9	50.3
1978[15]	37.3	8.5	38.9	23.8	36.7	19.7	31.8	22.7
1979	3.8[23]	10.1[24]	25.0[44]	49.8[55]	0.0[23]	11.3[24]	27.1[44]	40.8[55]

Table 24. Use of the general reservoir by recreational fishermen expressed as a percentage of the total number of anglers and hours fished for all areas surveyed in the Three Mile Island vicinity during the months of April-July 1974-1979. Data computed from the references cited.

	% of Total Anglers				% of Total Hours Fished			
	April	May	June	July	April	May	June	July
1974[39]	-	24.4	34.6	38.3	-	21.2	36.7	41.8
1975[40]	21.5	23.7	20.9	31.5	28.4	14.2	20.1	31.4
1976[57]	19.7	33.5	46.8	55.2	19.1	35.5	45.3	59.4
1977[14]	25.1	26.2	41.9	36.6	12.3	31.4	39.9	44.3
1978[15]	19.0	27.4	44.2	32.6	23.2	25.0	52.3	33.6
1979	16.2[23]	23.0[24]	35.7[44]	39.9[55]	17.7[23]	22.9[24]	36.8[44]	42.1[55]

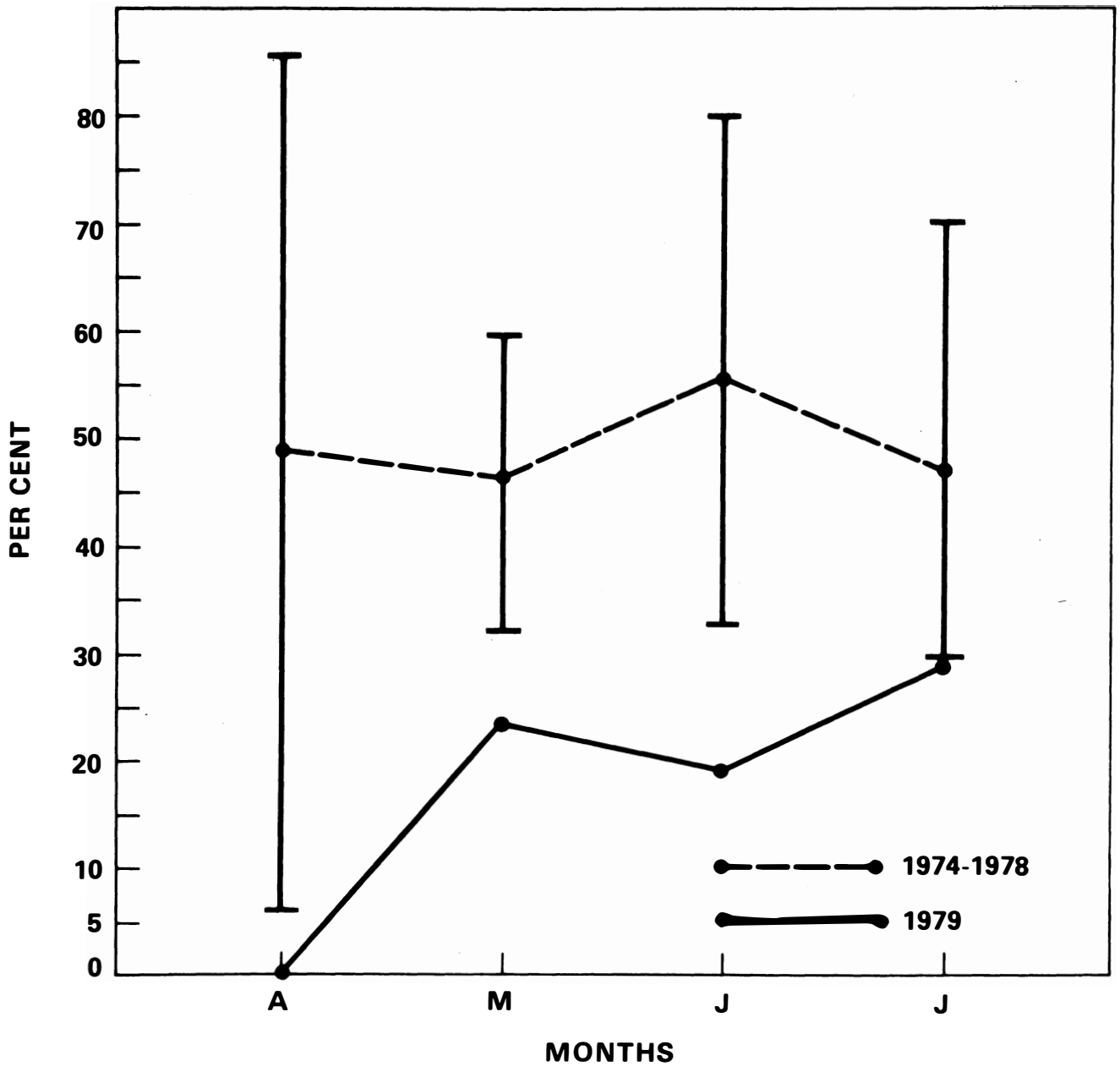

Figure 3. Recreational fishery harvest (% by number of the total fishes caught that were kept) from the general reservoir of the Susquehanna River in the Three Mile Island site vicinity during the months of April through July 1979 (solid line) and 1974-1978 (broken line; showing 5-year mean and range for each month, except April which are 4-year values).

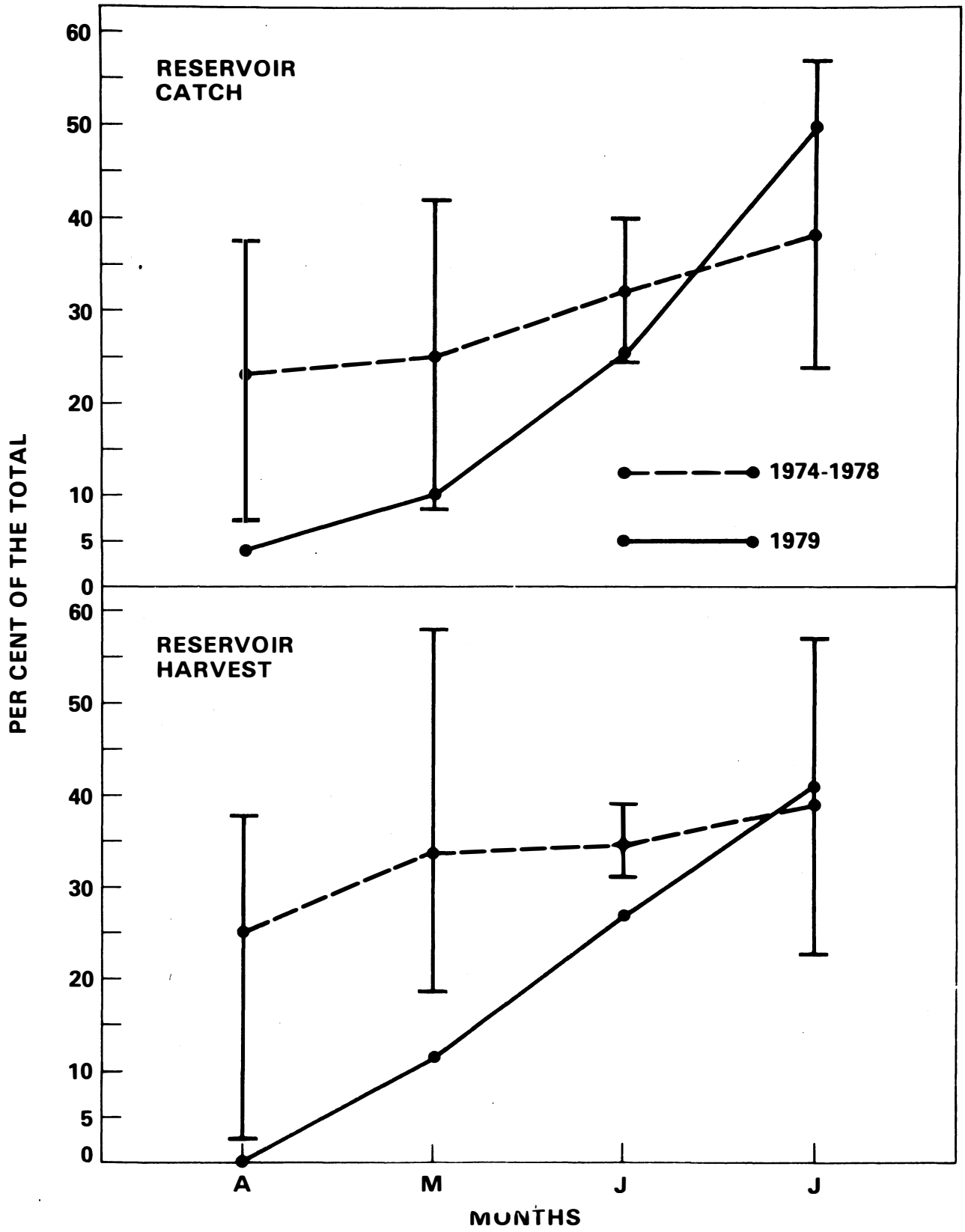

Figure 4. Relative contribution (% by number) of the general reservoir to the total recreational fishery catch (upper) and harvest (lower) from all areas surveyed in the Three Mile Island site vicinity during the months of April through July 1979 (solid line) and 1974-1978 (broken line; showing 5-year mean and range for each month, except April which are 4-year values).

E. Summary

1. The non-radiological aspects of station operations during and following the accident which potentially could have affected the aquatic biota of the Susquehanna River are related to thermal and chemical discharges.

   a) Thermal discharge and chemical discharge limitations established by the Commonwealth of Pennsylvania 401 Certification and NPDES Permit were not violated during the period of interest. The discharges which did occur (thermal, chemical, flow volumes) were all within the ranges of values previously analyzed in the FES and at the environmental hearing and found to be acceptable. River flows during the period were at seasonally high normal levels such that station discharges received considerable dilution.

   b) Based upon several years of studies conducted prior to the accident, the spatial extent of the thermal discharge plume was described. The measurable plume has been variable in extent and has been confined to very near the shoreline. Its maximum measurable extent has been to distances less than 20m offshore and 1000m downstream along the west shore Three Mile Island from the discharge downstream to a point about halfway between the discharge and the junction of the York Haven Dam with the Island. It is assumed that this area would constitute that portion of the river under the immediate influence of station discharges.

2. Biological data were being collected in the Susquehanna River upstream, downstream and near the nuclear station during the period of interest under the NRC ETS program. Summarized data made available to NRC by the licensee were anlayzed and compared with historical data from the site vicinity for the period 1974-1978.

   a) Since thermal and chemical dishcarges were not different from those of normal operation and did not violate effluent limitations, significant impacts to aquatic biota would not be expected. An examination of the biotic conditions was made which confirmed the absence of any detectable effects to benthic invertebrates and fishes.

      No unusual conditions of fish diseases or mortalities were noted in the river following the accident.

   b) Post-accident recreational fishing in the site vicinity did show departures from historical trends. Fishing appeared to partially shift emphasis form the reservoir in the immediate site vicinity to other areas, especially downstream near the York Haven Dam and the hydroelectric station. Anglers apparently fished less in the reservoir and those who did fish there returned more of their catches than in previous years. With time following the accident, the patterns of recreational fishing returned to normal or near-normal.

IV. Generic Aspects

A. Station Operation and Non-Radiological Effluents

Station operating conditions during and immediately following the accident resulted in releases of several hundred thousand-to-several million gallons of treated industrial waste effluent, in addition to cooling tower blowdown. In all cases where measurements were made, effluent limitations established by the NPDES permitting authority (Commonwealth of Pennsylvania) were not exceeded. Maintenance of the required quality of liquid effluents, therefore, appears not to have been impared as a result of the accident.

Knowledge by the non-nuclear engineering public that the reactor core was experiencing high temperatures and overheating difficulties during the accident, might have led one to wonder what magnitude of heat load was transferred to the Susquehanna River, and then, what impact it might have had on river biota and fisheries. Reactor design and operating conditions, however, resulted in a reactor trip and shutdown early during the course of accident events, so that the heat produced following shutdown was only a small portion of that produced during full power operation. In the case of the Three Mile Island accident, the removal of decay heat following shutdown also was less than normal due to a loss of immediate core cooling ability. The river discharge ΔT of up to 6.7°C during

normal reactor cooldown, therefore, was not realized, and thermal effluents during the accident were low.

Both chemical and thermal effluents to the Susquehanna River were maintained within established limitations and within the bounds of those analyzed during NEPA reviews prior to Unit 2 operation. That having been the case, as now known, it would be reasonable to expect that effects to the aquatic biota of the river also would have been within the bounds of acceptability as concluded in the pre-operational NEPA reviews. Examination of the biological data collected during routine non-radiological ETS studies in the site vicinity for a three month period following the accident (April through June 1979) confirmed the absence of any significant ecological effects. Spring conditions of increasing abundance of aquatic organisms and the onset of fish spawning during the historical April-June period were realized during 1979. Normal aquatic biological cycles apparently were undisturbed by non-radiological accident conditions.

The accident occurred during the early phases of the spring aquatic biological season - a time of transition from winter's low faunal abundance and productivity to spring's rapidly increasing faunal abundance and productivity. In a way, then, the timing of the accident was fortuitous for assessment purposes, in that if potentally harmful effluents had been released (and continued for some period of time), deviations from the normal spring productivity (in terms of species,

magnitude, or timing etc.) might have been recognizable and as causally related to accident conditions. This is contrasted with mid-summer or late fall conditions of decreasing abundance (or availability) of portions of the aquatic community. Had the accident occurred at those times, one could be faced with deciding whether downward biological trends were in some way related to accident events, or within the normal biological cycle only. Had the accident occurred during the winter months when aquatic productivity and faunal abundance are normally low, impacts could have been minimal, but not easily measured or detected. Additionally, aquatic biological sampling during months of extreme winter weather (cold, wind, ice, etc.) might have been suspended making an impact assessment difficult due to the lack of data.

The actual timing of the accident and the ready availability of site specific data (effluent quality and biological), however, permitted an evaluation which indicated that aquatic biological problems did not occur. It therefore seems reasonable to conclude that if the required limitations for non-radiological effluents are met during an accident, then the effects to the aquatic communities from those effluents should be minimal.

B. Data Availability and Data Needs

The availability of site specific data from ongoing studies prior to and following the accident and the existence of several successive years of

similar data (1974 through 1978) permitted a realistic assessment of observed effects rather than necessitating the conduct of a worst case analysis of potential effects. This was indeed fortunate since the accident was the first and only one of its kind. Had the accident occurred several years into the operational life of the station, it is possible that detailed site specific studies would not have occurred for several years, making a precise assessment of effects more difficult. Effluent quality can be measured throughout the life of a station under the NPDES program, however, and the knowledge that water quality can be controlled during accidents and that aquatic biota will be affected minimally (at worst) can be used in assessing effects realistically.

The ecological studies being undertaken by the licensee in the Susquehanna River have been greatly expanded in scope and complexity since their inception with the onset of Unit 1 operation in 1974. The data that were available for use in assessing effects of the accident were of a type and quality that were both useful and obtainable soon after collection. Data which proved to be of most practical use were those which:

1) defined the extent and relative locations of the effluent plume;

2) defined the fish species at sampling stations within the known area influenced by the plume; the use of several sampling gear types selective for various components of the fish community permitted the

identification of species potentially under the influence of the plume (and thus station discharges) from the rough, forage, and predator/sport segments of the community;

3) defined seasonal trends in species composition and abundance;

4) defined the types of disease and parasite conditions and the occurrence of fish kills and mortalities in the site vicinity;

5) defined the recreational fishery catches and harvests in absolute terms; from those, relative catches and harvests could be calculated for comparison between creel survey sites and among years; the ability of the creel survey program to reflect changes in fishing patterns during the post-accident period was most useful and permits analyses beyond those of ecological concern only, as discussed later;

6) defined water quality conditions in the river in and near the discharge and both upstream and downstream.

The monthly compilation and summarization of the ecological data by Licensee's consultant on a routine basis made the 1979 data rapidly available and in usable form. Similarly, those data on in-plant effluent thermal and chemical characteristics contained in the Discharge Monthly Reports submitted by the Licensee to the Pennsylvania Department of

Environmental Resources were both readily available and invaluable for assessment purposes. The provisional data on 1979 river flow in the form of computer printout supplied by the USGS at NRC request were also rapidly available and in usable form.

As stated, the rapid availability of usable data permitted a realistic assessment of observed effects. This probably represents a "best case" condition, however, since such a set of circumstances might not always occur. It is conceivable that future nuclear plants could be permitted to operate without having performed any ecological studies during years of actual reactor operation, if their potential impacts are found to be minimal and acceptable during pre-operational NEPA reviews. Were that to be the case at a plant experiencing (or which just experienced) an accident, perhaps only pre-operative data and predictive assessment conclusionary information (EIS, predictive models, etc.) might be available, with the exception of any in-plant NPDES effluent monitoring data that might be required. Without actual operational biological and related data which define historical trends in the biotic system with respect to station operational characteristics (and vice versa), realistic assessments of accidents (or other non-accident unusual events of potential ecological significance) might not be possible. Operational

monitoring of aquatic biota, therefore, might have more far reaching application than merely defining the impacts of a nuclear plant under normal operating conditions only. It might serve to define, for example, such data needs as discussed in items 1) through 6) above. Monitoring of aquatic biota for a given period of time prior to and during the first years of plant operation, therefore, could be used to satisfy the needs of the NPDES permitting authority, as well as provide data useful for assessment of unusual events, should they occur some years later.

It is recognized that even if detailed studies are conducted during the first few years of station operation, their usefulness would be reduced with time, especially for an accident or event which occurred well into the life of a reactor (i.e., 20-30 years). Periodic monitoring of selected biotic parameters could provide useful information updates throughout the life of a nuclear plant. Whether this is practical or desirable, however, is not a subject for debate here. If for the sake of discussion, it is assumed that an event occurs many years after the termination of operational studies, and no periodic update monitoring has

occurred, what type of information might be expected to be readily available for assessment purposes? Site specific data probably would be available on some point source effluents under the NPDES monitoring program. Although current site specific data on fish species occurrence and distributon might not be available, historical fish impingement data (if available) could be compared with fishes impinged following an incident. Impingement sampling does not require expensive equipment or time consuming efforts to obtain data, as compared with making ready with boats, nets, and personnel. As long as a nuclear plant is withdrawing condenser cooling water through traveling screens, the potential for collecting data on fish species composition and seasonality is there. During operational monitoring programs conducted in the first years of station life, therefore, an objective could be to define quantitatively the usefulness and site-specific limitations of using impingement as a readily available source of data to be used on short notice. If impingement is determined to be useful, periodic monitoring might concentrate more on impingement than farfield netting studies. The usefulness of impingement as a sampling tool has been investigated, with promising results, when it is standardized against conventional sampling gear types and when used for specific purposes under which its limitations are known.[52/]

Studies at Three Mile Island during 1978 showed that significant differences existed between fish species ranks in impingement samples compared with seine samples collected on the west shore of the Island.

Species composition also was more closely related for impingement samples at each intake than between impingement and seine samples.[15] During 1979, impingement samples were not collected at Three Mile Island during April due to the nuclear accident.[23] Data for March[22] and May,[24] however, do show that the farfield sampling techniques (seine, trapnet, electrofisher) captured many more individuals and species than did impingement. The Units 1 and 2 intakes are shoreline structures located several hundred meters upstream of the main station discharge. As such, fish species impinged could be assummed to be some of those which probably would be found in the downstream shorezone area under the influence of the effluent plume. During March of 1979, impinged fish species included spottail shiner, spotfin shiner, tessellated darter, banded darter, channel catfish, rock bass, smallmouth bass, walleye, marginated madtom, shield darter, and pumpkinseed. Similar species were impinged during May 1979 and were also taken at sampling stations downstream of the discharge during the period of the nuclear accident. If far-field netting studies had not been required, precise information on fishes near the station discharge would not have been known. Examination of impingement catch data prior to the accident (if such sampling were ongoing, which it was) and/or following the accident could have provided general information on the species present along the west shore of Three Mile Island and thus potentially in the area of station discharges. Actions then could have been directed toward collecting and studying identified fishes, including recreational fishery species (channel catfish, basses, sunfish, walleye) and forage species (shiners, darters).

A knowledge of the location and extent of the effluent plume and fish species likely to be near or potentially under its influence would be a reasonable starting point for investigation during or following a potentially significant environmental event. This would also dictate where stressed or dead fishes might be found during a visual inspection. Such specimens (if found) could be used for both impact assessment and post mortem pathology work for establishing presence or absence of a causal link relationship between plant operation and mortality. A knowledge of pre-incident or normal levels of pathology and mortality (if known) would also be useful for comparative purposes. These could be other objectives of monitoring programs conducted during the early years of station life. In the absence of site specific creel survey data, current information on the recreational fisheries can often be obtained from state fish and game agencies and their biologists and wardens.

C. Application of Non-Radiological Findings for Radiological Assessments

The examination and findings of the non-radiological consequences of the accident might be applicable for some aspects of the radiological assessment of the accident at Three Mile Island, and for radiological assessment in general.

The thermal plume mapping results provided insight into the location and extent of the thermal plume in the Susquehanna River. This information could be used in deciding upon sampling locations for river water and

sediment radiological content and for obtaining fishes for radiological analysis which might have been in the immediate plume area and subject to relatively high doses prior to substantial effluent dilution with river flows. The present non-radiological study was able to determine that several species of forage and predator/sport fishes were in the plume area following the accident.

This study also examined the background information on fish disease and mortality conditions by type and species, as known for the site area. Such historical data could be used for comparison and follow-up after an accident or radiological release event for short-term (mortalities) and long-term (disease) effect studies, as potentially causally related to releases.

An examination of the recreational fishery in the Three Mile Island area following the accident compared with historical data showed that fishing patterns in the immediate site vicinity (reservoir) were altered. During the month of April immediately following the accident, anglers fishing in the reservoir were noted as having kept none of their catches. This suggests that the liquid radiological pathway leading to man via finfish consumption was absent, or at worst, very small in the immediate receiving waters (the reservoir) of station effluents. If, however, fishing emphasis following the accident did shift from the reservoir to downstream areas such as the York Haven Dam or the hydrostation tailrace, then the liquid pathway to man could have been present through finfish consumed from

those areas. A form of voluntary pathway interdiction might have been exercised by the anglers fishing the reservoir, however. The Liquid Pathway Generic Study [54] discusses interdiction following nuclear accidents, one form of which is controlling radiological exposure to the public by controlling the link in the food chain to man. One method for accomplishing that is prohibition or some form of control of finfishing and fish caught in the area, such as has been done following chemical and biological contamination of fishing areas. If finfish control measures are to be initiated for a land-based riverine site following a large-scale nuclear accident, the Liquid Pathway Generic Study suggested that initiation occur soon after (within days) and continue for a limited duration time period (weeks). It appears that those control criteria might have been met on a voluntary basis for reservoir fishing for about a month following the March 28 accident. On the first survey period in May 1979 (Sunday May 6), 54 anglers interviewed caught 66 fish and kept 6 (9.1% harvested) from the reservoir. A factor which probably aided in reduced fishing and catch retention in April was that the legal harvest season for some desirable species had not yet opened - May for walleye, northern pike, and muskellunge; and June for smallmouth bass.[53]

This study has examined the data needs and potential sources of aquatic biological data which could be obtained quickly for first-round qualitative uses, when more detailed studies might not be ongoing. Some of the data sources applicable for radiological uses could be: fish impingement collections on the traveling screens; visual inspections for

fish kills; recreational (and commercial) fisheries information obtained from knowledgable state resource agencies; data on plume location, species present there, and fish diseases and mortalities from properly planned preoperative and operative studies conducted previously. Such first-round sampling measures (along with others as appropriate) could be initiated as part of an emergency data gathering program, prior to any full scale monitoring which might occur following a nuclear accident.

The incorporation of non-radiological studies and findings into radiological assessments (as appropriate) can aid in the conduct of a meaningful and realistic overall assessment of the consequences of nuclear accidents.

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16. ABSTRACT *(200 words or less)*

The non-radiological consequences to the aquatic biota and fisheries of the Susquehanna River from the March 28, 1979 accident at Three Mile Island Nuclear Station were investigated through the post-accident period of July 1979. Thermal and chemical discharges during the period did not exceed required effluent limitations. Several million gallons of treated industrial waste effluents were released into the river which were not of unusual volumes compared with normal operation and were a small proportion of the seasonally high river flows. The extent and relative location of the effluent plume were defined and the fishes known to have been under its immediate influence were identified, including rough, forage, and predator/sport fishery species.

No impacts to benthic invertebrates or fishes were detected. No unusual conditions of fish disease or mortalities were noted. Normal seasonal increases in faunal abundance and species composition occurred, as did the onset of the fish spawning season in April. Post-accident recreational fishing patterns temporarily departed from historical trends, most notably during April when Anglers returned an unprecedented 100% of their catches. Several generic aspects are discussed, including: impact detection; data needs; and the applicability of the findings for radiological assessment.

17. KEY WORDS AND DOCUMENT ANALYSIS

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