U-601645
L30-90(04-16)-LP
1A.120

ILLINOIS POWER COMPANY

CLINTON POWER STATION, P.O. BOX 678, CLINTON, ILLINOIS 61727

'pril 16, 1990

Docket No. 50-461

Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: Clinton Power Station
<u>Annual Environmental Operating Report</u>

Dear Sir:

In accordance with Appendix B to Facility Operating License NPF-61, Illinois Power Company (IP) is submitting the Annual Environmental Operating Report (Attachment 1). This report covers the period January 1, 1989 through December 31, 1989.

Sincerely yours,

F. A. Spangenberg

F. A. Spangenberg, III
Manager - Licensing and Safety

WSI/csm

Attachments - 5 (Available upon request)

cc: Regional Administrator, Region III, USNRC (w/o attachment)
NRC Clinton Licensing Project Manager (w/o attachment)
NRC Resident Office (w/o attachment)
Illinois Department of Nuclear Safety (w/o attachment)

IE25
1/1

Annual Environmental Operating Report

The Environmental Protection Plan (EPP) for Clinton Power Station requires that the Annual Environmental Operating Report shall include:

(A) A list of EPP noncompliances and the corrective actions taken to remedy them.

(B) A list of all changes in station design or operation, tests, and experiments made in accordance with Subsection 3.1 which involved a potentially significant unreviewed environmental issue.

(C) A list of non-routine reports submitted in accordance with Subsection 5.4.2.

(D) Any results and/or assessments for the environmental monitoring programs described in Subsection 2.0 of this EPP which were submitted to the respective regulatory agencies during the annual reporting period.

The following provides the Illinois Power Company response to each listed item.

A. Listing of EPP noncompliances and corrective actions:

1) <u>Noncompliance</u>:

A Total Suspended Solids (TSS) sample obtained April 3, 1989 from Outfall 008 yielded 38 ppm TSS, an exceedance of the 30 ppm permit limit.

<u>Corrective Action</u>:

The sample result is believed to be due to the excessive rain which agitated the pond and surrounding areas, as no other aberrant conditions existed. CPS no longer discharges from the Equipment Maintenance Building; therefore, the entire in-coming flow is attributable to natural runoff. Subsequent samples taken on April 10 and April 17, 1989 were both within permit limits. No further actions were taken.

2) <u>Noncompliance</u>:

On August 18, 1989, chlorine was discharged into the inlet of the Circulating Water Pumps for 2 hours and 6 minutes. This length of time exceeded the 2 hour chlorine discharge time for the 24 hour period.

<u>Corrective Action</u>:

This incident is perceived to have occurred because Operations personnel were not cognizant of the requirements.

The Operations Department has disseminated this information to its personnel to ensure this event does not recur. It should also be noted that chlorine levels did not approach the permit limit in the flume (Outfall 022) at the second drop structure and remained below detectable levels for the duration of the discharge.

3) <u>Noncompliance</u>:

On August 23, 1989, a composite sample for Biological Oxygen Demand (BOD) was not taken at Outfall 002a. Only a grab sample was collected from the Sewage Treatment Plant inlet.

<u>Corrective Action</u>:

A grab BOD sample from the plant's inlet and the composite effluent sample are required per the NPDES checklist for process control purposes. Only one sample bottle was provided to the technician for sampling and the composite requirement was missed.

The involved technician was counselled and the checklist was revised to make requirements more obvious. In addition, the Total Suspended Solids sample for that date and outfall is well within specifications, as were all other process control parameters, indicating that a properly obtained BOD sample would have yielded satisfactory results.

4) <u>Noncompliance</u>:

The BOD sample for Outfall 002a of August 30, 1989, yielded results which were not representative of the system because organic material potentially coated the detection probe for this analysis. Consequently, the accuracy checks for this analysis were not within tolerance and all analytical results for this date and outfall were invalidated.

<u>Corrective Action</u>:

Illinois Power's Central Laboratory investigated the problem and resolved the difficulties by replacing the probe membrane and thoroughly cleaning and recalibrating the instrument. All subsequent analyses have been within the prescribed parameters.

B. List of changes in station design or operation, tests, and experiments made in accordance with Subsection 3.1 which involved a potentially significant unreviewed environmental issue:

No changes were made in this time period to station design, operation, tests, or experiments which involved a potentially significant unreviewed environmental issue.

C. The following is a non-routine report submitted in accordance with Subsection 5.4.2:

About 200 gallons of very light transformer mineral oil was released from the spare main power transformer at the Clinton Power Station during the period from 12:15 a.m. to 2:45 a.m. on Thursday, July 20, 1989. Station personnel did not become aware of the release until approximately 6:40 a.m.

The exact quantity of oil which flowed past earthen containment structures and into Clinton Lake is unknown. A thin sheen of oil was observed on the lake at daybreak. This sheen covered a narrow area of the lake 500 to 1,000 feet south of the water intake for the plant. There were no PCBs (polychlorinated biphenyls) in the oil and there was no observed impact on aquatic life. The transformer is not used in normal plant operations and is not exposed to radioactivity at any time.

Contract technicians from General Electric were refurbishing the spare transformer when the spill occurred. The technicians were filtering mineral oil from a component at the top of the transformer called the Atmoseal tank. The oil was being filtered to rid it of unwanted ceramic particles. During this process, oil is drained from the transformer to a trailer where it is filtered and pumped back into the tank. A pressure buildup in the Atmoseal tank caused a three-inch by one-sixteenth inch fissure in a welded seam of the tank and oil was ejected as a fine spray from the tank. GE personnel did not notify CPS personnel of the release. During the 2.5 hour period of the release it was raining heavily.

The transformer holds about 11,000 gallons of oil, and was about 1,000 gallons below capacity at the time of the accident. As is standard procedure will all transformers, containment structures were built as a safeguard in the event of an oil spill. However, these proved inadequate because (1) the oil was sprayed overtop the containment to some extent and (2) the heavy rains exceeded the hydraulic capacity of the containment previously constructed in a nearby earthen channel.

Personnel at the plant acted swiftly to contain the spill and control the impact of the sheen on the lake. Strands of floating booms, made of highly absorbent material, were placed in the water to prevent the sheen from moving farther out into the 12-mile lake. The station's water intake pumps were turned off to prevent water from entering the plant and to keep the water calm near the sheen. Crews removed the oil using absorbent pads to blot the affected area and absorb the oil.

As a result of this incident, GE personnel have been advised that all releases of oil must immediately be brought to the attention of CPS personnel. In addition, the containment around the transformer has been enlarged.

D. Results and/or assessments for the environmental monitoring programs described in Subsection 2.0 of this EPP which were submitted to the respective regulatory agencies during the annual reporting period:

1. The final report on Clinton Lake Naegleria fowleri Monitoring was submitted on June 19, 1989 (with additional information provided on July 31). The power station was in full operation during 1988. N. fowleri was isolated from several sites on the heated arm of Clinton Lake from both surface and bottom samples indicating a wide distribution through the water column. The amoeba was not recovered from the ambient temperature arm of the lake. This information is provided in Attachment A.

2. Clinton Lake water temperature data was submitted to the Illinois Department of Public Health for the periods of March 31 to May 16, 1989 and July 13 to October 4, 1989. This information is related to N. fowleri studies and is provided in Attachment B.

3. In accordance with Special Condition No. 9 of the National Pollutant Discharge Elimination System (NPDES) Permit IL0036919, IP submitted the Biological Report to the Illinois Environmental Protection Agency (IEPA) on October 19, 1989. This report compared the findings from the Environmental Monitoring Program conducted from May 1978 to December 1986 (preoperational) to the findings from January 1987 to December 1988 (postoperational). The purpose of the report was to comprehensively characterize the condition of Clinton Lake before and after the release of warm water discharges from Clinton Power Station with respect to the monitoring of the following biological parameters: periphyton, phytoplankton, zooplankton, benthos and fisheries.

   In lieu of transmitting the entire five volumes of the Biological Report, an executive summary of the report is provided as Attachment C.

4. In accordance with section 5.0 of the Operational Monitoring Plan approved by the Illinois Environmental Protection Agency on July 1, 1986, the Water Quality Report was submitted to the Illinois Environmental Protection Agency on October 19, 1989. This report discussed the water quality monitoring performed by Illinois Power on Clinton Lake during the 1978 to 1988 time frame (this period includes the first two years of Clinton Power Station operation). Rather than transmitting the full volume of water quality data, the introduction to the report is provided as Attachment D.

Attachment A

Clinton Lake *Naegleria fowleri* Monitoring

0-600758
L65-89(06-19)-LP
8D.150

ILLINOIS POWER COMPANY

500 SOUTH 27TH STREET, DECATUR, ILLINOIS 62525-1805

June 19, 1989

Mr. David Antonacci
Division of Environmental Health
Illinois Department of Public Health
535 W. Jefferson Street
Springfield, Illinois 62761

Dear Mr. Antonacci:

Clinton Lake 1988 Naegleria fowleri Monitoring Report

Enclosed is a copy of the 1988 survey for Naegleria fowleri conducted on Clinton Lake. Dr. Huizinga of Illinois State University, performed the survey and prepared the report. As previously discussed, we will meet with you at 10:00 A.M. on June 22, 1989 to review and discuss the report.

The 1988 study represents the second year of operational monitoring and completes our agreement to monitor for Naegleria fowleri for two years after the start-up of Clinton Power Station.

We look forward to seeing you on June 22.

Sincerely,

ILLINOIS POWER COMPANY

James A. Smithson
Supervisor - Field Biology

Encl.

JAS7:dmf

SURVEY OF CLINTON LAKE FOR THE OCCURRENCE OF *NAEGLERIA FOWLERI*

Harry W. Huizinga, PhD.
Department of Biological Sciences
Illinois State University
Normal, Illinois 61761

May 23, 1989

SUMMARY

A survey of Clinton Lake for the free-living amoeba *Naegleria fowleri* was conducted during 1986,1987 and 1988; before and after the Clinton Power Station began production and the release of heated effluent. *N. fowleri* was isolated in 1986 before production, and in 1987 during a period of intermittent testing. During 1988 when the power station was in full production, an increase in the isolation of *N. fowleri* was observed. *N. fowleri* was isolated from several sites on the heated arm of the lake, but was not recovered from the ambient temperature arm. The amoeba was recovered from surface and bottom samples indicating a wide distribution through the water column.

INTRODUCTION

The free-living amoeboflagellate, Naegleria fowleri, is the causative agent of primary amebic meningoencephalitis, a rare but rapidly fatal human central nervous system disease (John, 1982; Marciano-Cabral, 1988). N. fowleri has been recovered from thermally elevated aquatic environments throughout the world ((DeJonckheere and Van de Voorde, 1977; Tyndall, 1985; Tyndall et al. 1989). N. fowleri is considered ubiquitous, but the environmental factors which induce or select for the pathogenic amoeba are incompletely understood. Griffin (1972) determined that N. fowleri tolerates high temperature and an isolation temperature of 45C is used to separate mixed populations of free-living amoebae isolated from the environment. N. fowleri is thermophilic and develops in laboratory culture at 45C, a temperature that excludes non-thermophilic species of amoebae.

Griffin (1983) proposed the "flagellate-empty environment hypothesis" to explain the increased prevalence of N. fowleri in artificially heated aquatic environments. The hypothesis states that increased temperature decreases the numbers of non-thermophilic amoebae and reduces their competition with thermophilic forms of N. fowleri; the latter multiply to occupy the amoeba empty habitat.

The purpose of this study was to assess the effects of thermal effluents released by the newly operational Clinton Power Station on the occurrence of N. fowleri in Clinton Lake.

Background and Previous Studies of Clinton Lake

Tyndall (1985)and Tyndall et al.(1989) surveyed power plant cooling reservoirs in the United States and determined that the prevalence of N. fowleri increased when water temperatures were artificially elevated by power plant cooling effluent. Tyndall and Dominique (1983) isolated thermophilic amoebae from three cooling lakes in Illinois: Baldwin, Vermillion and Clinton Lakes. They found pathogenic N. fowleri in Baldwin Cooling Pond which receives heavy thermal enrichment. Pathogenic N. fowleri were not isolated from Clinton Lake samples, but a high prevalence of thermophilic amoebae was found in sediment samples. They isolated a strain of Acanthameba lenticulata from Clinton Lake that was pathogenic to mice.

An amoeba survey of Clinton Lake was conducted during the summer of 1986, before the Clinton Power Station began operation (Huizinga, 1988). Thermophilic strains of Naegleria were isolated, and one N. fowleri isolate was collected. Wellings (1987) performed an amoeba survey of Clinton Lake before the Clinton Power Station was operational and recovered a single N. fowleri isolate during October, 1986. Based on these studies, and other surveys of power plant cooling lakes in the United States and Europe (De Jonckheere and Van de Voorde, 1977; Tyndall, 1985), it was predicted that N. fowleri would be amplified in Clinton Lake following prolonged temperature elevation.

MATERIALS AND METHODS

1. Study Areas and Collection Sites

The "V"-shaped Clinton Lake was divided into two study areas: 1) the Salt Creek or east arm was designated the "heated arm" receiving effluent from the Clinton Power Station and 2) the North Fork of Salt Creek or west arm was designated the "ambient arm" of the lake (Fig. 1). Thermal effluents enter the lake at the end of the discharge canal (site 4) and sites 2-9 on this portion of the lake are considered heated sites. Heat is dissipated as water moves down the east arm and the temperatures of sites 10-16 on the west arm are not raised above ambient (personal communication, James Smithson, Illinois Power Company). Amoeba collection sites were selected in the heated and ambient arms of the lake to be representative of environmental conditions suitable for the presence of amoebae and for comparative study of the two arms of the lake.

Two numbering series were used to identify collection sites : 1) the collection sites of Huizinga, which are part of an ongoing three year study, are designated H, 1-16, 2) the Illinois Power Company collection sites are designated by I.P. numbers which are part of a separate study. Ten of the sites from the two studies are identical. Partial data from sites H-3,7,9,10A,11,and 13 sampled by Huizinga during a separate study in 1986, 1987 and May through July, 1988 are included in this report to provide an overall understanding of the three year study.

2. Sampling Procedures

Samples of water and sediment were collected by Illinois Power Company biologists during the August through December , 1988 study period. Samples were collected by Huizinga during 1986, 1987, and May through July, 1988. Throughout the entire study, samples were taken at each site by the following procedure: 1) surface water sample with a hand-held jar 2) bottom sediment (1000 ml) with an Eckman or Ponar dredge. Samples are designated surface (S) and bottom (B) in all data presentations.

3. Amoebae Isolation Procedures.

A) Isolation of Amoebae from Water Samples

Water and sediment samples were transported to the laboratory and processed immediately. Each sample was mixed thoroughly and an aliquot sample (100 ml) was removed and filtered through a cellulose filter (1.2 millimicron pore size, 97 mm, Spectrum Microfilter). The filter was inverted on a non-nutrient agar plate (15x100 mm) coated with a lawn of live Enterobacter cloacae bacteria (cultured 24 hours at 37C). Test plates were incubated at 45C in high humidity,constant temperature tissue culture incubators. Cultures were examined at 24, 48 hours and for up to 7 days post isolation for growth of amoeboid plaques as amoebae fed on bacteria and multiplied.

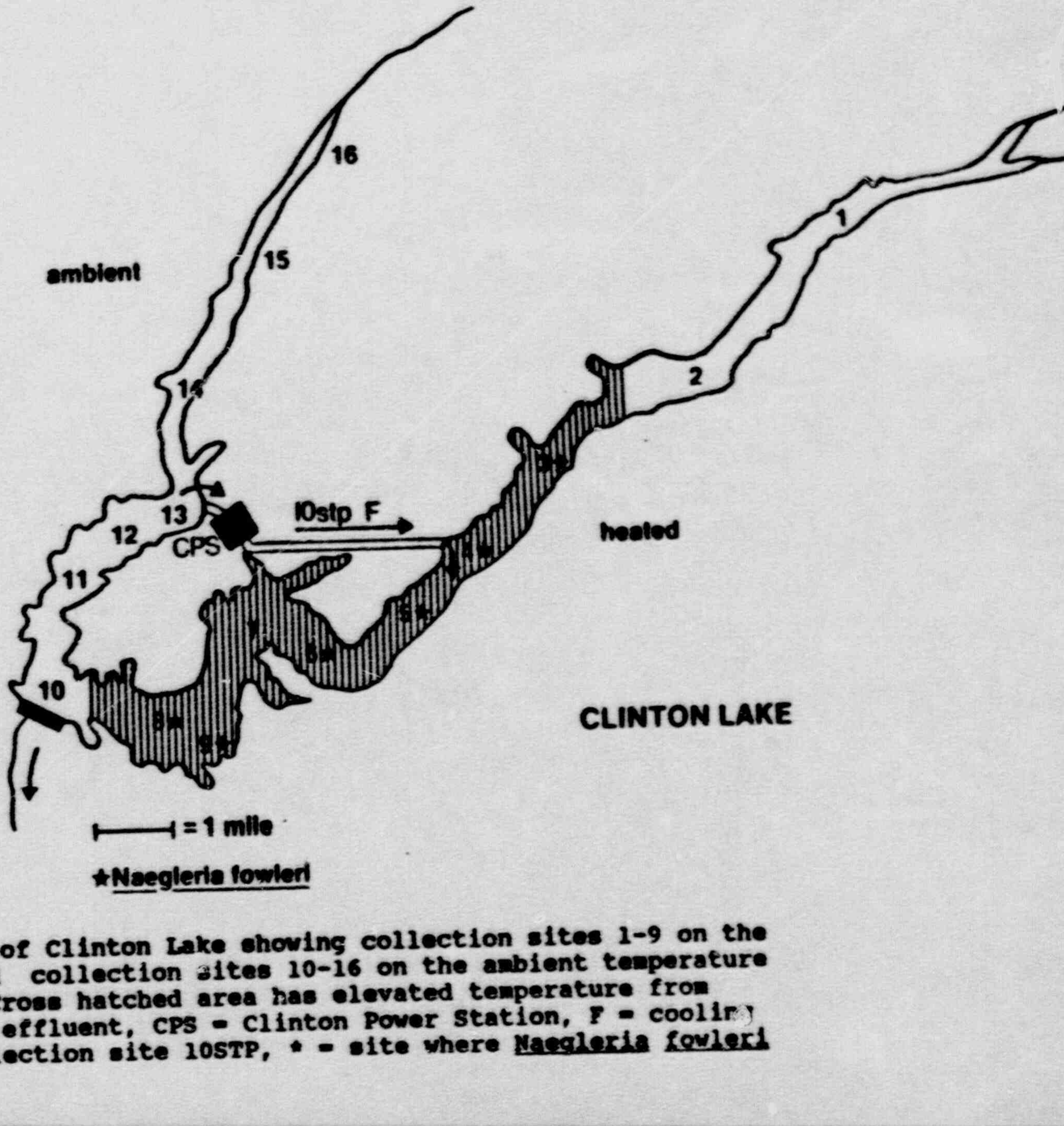


Figure 1. Map of Clinton Lake showing collection sites 1-9 on the heated arm and collection sites 10-16 on the ambient temperature arm. Legend: Cross hatched area has elevated temperature from power station effluent, CPS = Clinton Power Station, F = cooling flume and collection site 10STP, * = site where *Naegleria fowleri* was isolated.

B) In-vitro Cultivation of Amoebae

Amoebae are harvested from agar- E.cloacae , plates and cultivated in axenic culture in 15 ml screw-capped culture tubes using Balmuth/Nelson medium (Weik and John, 1977) supplemented with calf serum and appropriate concentrations of penicillin, streptomycin and kanomycin sulfate to inhibit bacterial growth. Amoebae were cultivated to log phase 48 hr at 37C, harvested and used in identification procedures and mouse tests.

4. Amoeba Identification Procedures

Amoebae isolated in culture were studied microscopically and characterized by: morphology of trophozoite and cyst stages, and type of pseudopodial movement (Page, 1967; Page, 1976). Naegleria spp. undergoes a morphological change from the amoeboid trophozoite to the biflagellated form (enflagellation) when placed in distilled water or Page's amoeba saline. Trophozoites are tested for enflagellation by incubation in Page saline at 37C for 3 hours. Amoeba isolates that did not enflagellate (presumed Acanthamoeba spp.) were identified by morphological criteria (Page, 1967). The Concanavalin A agglutination reaction was used to separate N. fowleri (non-agglutinating) from other species of Naegleria which agglutinate in the presence of Concanavalin A (Josephson et al. 1977).

A) DNA Fingerprinting Analysis

Restriction fragment length polymorphism (RFLP) analysis is an established method for identifying pathogenic microorganisms, including viruses, bacteria, and protozoa. Amoebae contain unusually highly repetitive, simple DNA which is extracted and analyzed using methods developed by Mc Laughlin et al.(1988). The DNA fingerprints of Clinton Lake isolates were compared with known N. fowleri (Lee strain).

B) Identification Criteria for N. fowleri.

Amoeba isolates were identified as N. fowleri if they satisfied all of the following identification criteria: thermophilic growth at 45C in E.cloacae /agar and Balmuth/Nelson medium, enflagellation at 37C, non-agglutination in concanavalin A, DNA fingerprinting and homology with known human strain of N. fowleri (Lee strain), and pathogenicity to mice by intranasal inoculation. Other isolates which satisfied all of the above identification criteria, but were non-pathogenic to mice, were identified as Naegleria species unknown.

C) Amoeba pathogenicity test in mice.

Concentrated dosages of 10^5 amoebae from culture were inoculated into the nasal cavities of weanling Balb-C mice (Martinez et al., 1973; John and Nusbaum, 1983). Mice were examined for signs of nervous system involvement (meningoencephalitis) which are caused by pathogenic strains of N. fowleri during days 3-14 postexposure. Mice showing signs of illness were euthanized by cervical dislocation. Brain tissue was aseptically removed with a sterile pipette and transferred to E.cloacae /agar plates and Balmuth-Nelson medium to reisolate amoebae and verify amebic infections of mice.

5. Quality Controls.

To test the relability of isolation procedures, six quality controls were run for each monthly sample period (August-December,1989). Samples of Clinton Lake water were autoclaved to eliminate amoebae. Known laboratory cultures of N. fowleri (3 Lee strain, and 3 Clinton Lake 8B2) were added to each of six water samples which were processed by standard isolation procedures described above. The Lee strain was isolated from a human case of meningoencephalitis. The Clinton 8B2 strain was isolated from Clinton Lake during July, 1988 and was identified as N. fowleri based on the above described criteria.

RESULTS

An amoeba survey of Clinton Lake was conducted during 1986, 1987 and 1988; before and after the Clinton Power Station began production. A phase of the study conducted prior to August, 1988 was not funded by Illinois Power Company, but data are included to provide a complete understanding of the occurrence of N. fowleri in Clinton Lake. Amoeba isolation data are summarized in (Figure 1, Table 1). A single isolate of N. fowleri was collected during July, 1986, before the Clinton Power Station began operation. During July and October, 1987, two isolates were collected from site 4 when the station was in a period of testing and heated water was periodically released into site 4 (Fig. 1). During 1988 when the power station was on line and releasing a continuous thermal effluent, 21 N. fowleri isolates were collected in the heated arm from May through October (Figure 1, Table 1).

The second phase of the Clinton Lake amoeba survey was conducted during the months of August, September, October and December, 1988 (supported by a research contract from the Illinois Power Company). N. fowleri was isolated from stations 3,4,5, 6 and 8 on the heated arm. N. fowleri was not collected from sites 10,11,12, and 13 on the ambient temperature arm of Clinton Lake (Figs.1 and 2, Table 2). N. fowleri was not collected from sites 1 and 2 upstream from the thermal discharge at site 4. N. fowleri was isolated during all months sampled except December, 1988 (Tables 3-7, appendix). Mixed populations of Naegleria spp. were collected from all stations on both arms of the lake (Fig.2, Tables 3-7, appendix).

The numbers of pathogenic N. fowleri isolated from the surface (S) and bottom (B) were proportionally similar during the months of September (3S and 3B) and October (1S and 1B) suggesting that N. fowleri is distributed throughout the water column of the lake (Fig. 2). Thermophilic Naegleria spp. were

Table 1. AMOEBA ISOLATION FROM CLINTON LAKE IN RELATION TO WATER TEMPERATURE BEFORE AND AFTER THERMAL PRODUCTION BY CLINTON REACTOR 1986-1988.

COLLECTION PERIOD	MEAN WATER TEMP. (C)	HIGH WATER TEMP. (C)	NUMBER SAMPLES	NUMBER THERMO-PHILIC ISOLATES (45C)	COLLECTION SITE: NO. PATHOGENIC ISOLATES	
1986 BEFORE PLANT OPERATION, NO THERMAL PRODUCTION						
JULY	30.4	31.5	28	21 (75%)	9B:1	
AUGUST	25.9	26.0	34	16 (47%)	0	
SEPTEMBER	25.8	27.5	34	19 (55%)	0	
OCTOBER	12.8	14.2	34	18 (53%)	0	(subtotal 1)
1987 PLANT TESTING, INTERMITTANT THERMAL PRODUCTION						
APRIL	6.3	7.0	12	5 (42%)	0	
MAY	23.6	26.5	24	7 (29%)	0	
JUNE	24.7	29.0	26	4 (15%)	0	
JULY	30.9	37.0	48	9 (19%)	4S:1	
AUGUST	32.0	35.1	26	7 (27%)	0	
SEPTEMBER	23.6	27.0	10	3 (30%)	0	
OCTOBER	19.0	29.0	26	14 (53%)	4S:1	(subtotal 2)
1988 FULL PLANT OPERATION AND THERMAL PRODUCTION						
MAY	21.3	30.1	26	12 (46%)	0	
JUNE	29.7	37.2	26	11 (42%)	4S:1,4B:2,5B:1, 6B:1,8B:1	
JULY	32.0	37.5	28	16 (57%)	4S:1,5S:1,6B:1, 8B:1	
AUGUST,16&30*	30.6	41.7	128	61 (48%)	3B:1,6B:1,8S:1	
SEPTEMBER	23.4	32.2	64	37 (58%)	3S:1,4S:1,4B:1,5S:1, 5B:1,6B:1	
OCTOBER	17.6	25.8	64	17 (27%)	5S:1,5B:1	
DECEMBER	5.2	10.7	44	9 (20%)	0	(subtotal 21)

*two samples for August combined

Total Pathogenic Isolates - 24

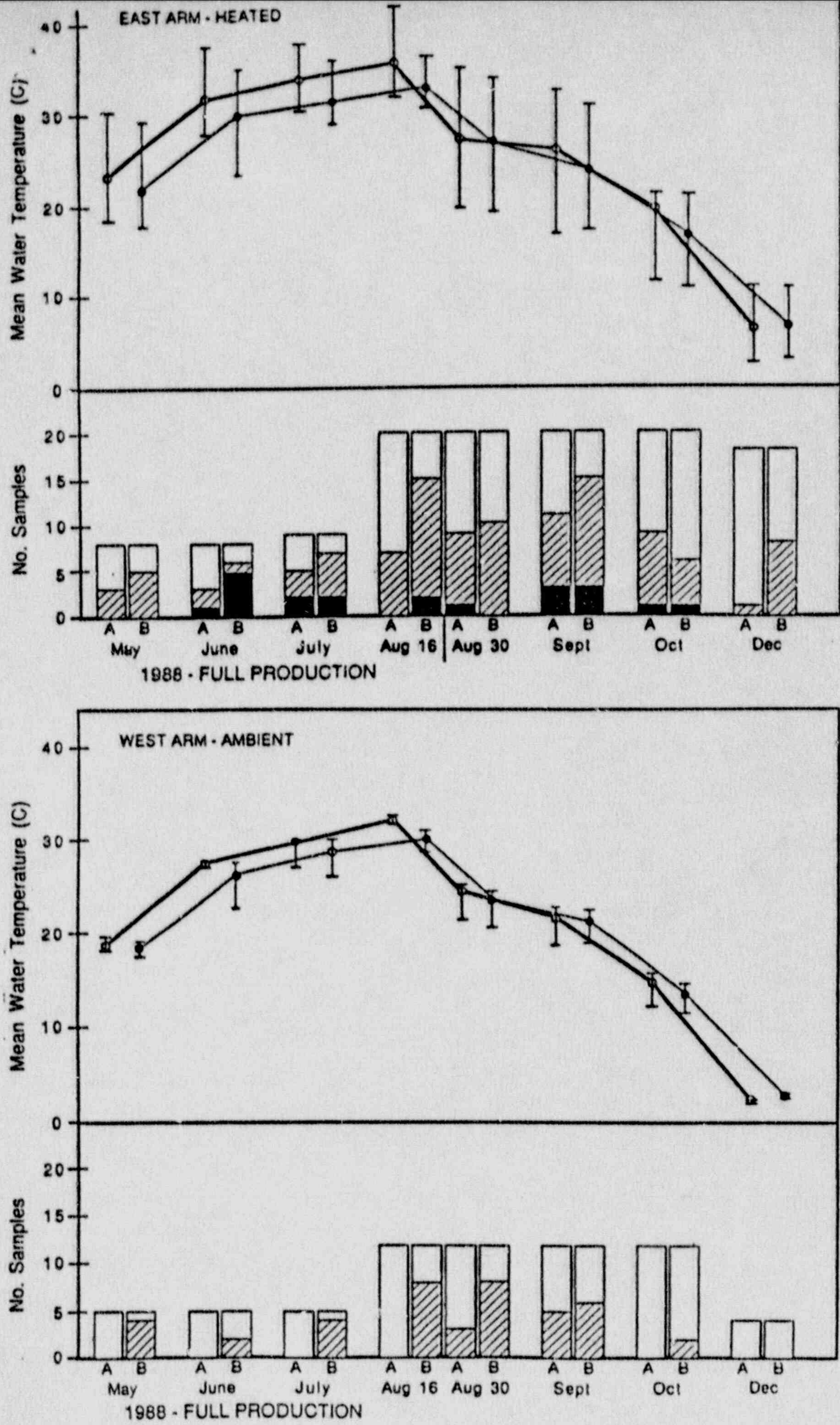


Figure 2. Amoeba survey of Clinton Lake during May - December, 1988 when Clinton Power Plant was in full production, showing amoeba collections from the ambient and heated arms of the lake. Legend: open bars - negative isolates, cross hatched bars - thermophilic amoeba isolates, solid bars - *N. fowleri* isolates, A - surface water sample, B - bottom sediment sample, open circle - surface water temperature, solid circles - bottom water temperature, vertical lines - maximum and minimum temperature.

Table 2. Summary of the distribution of *Naegleria* spp. and *Naegleria fowleri* by collection site and sample type, August through December, 1988.

Sample Site	Total No. Samples	No. of *Naegleria* spp.		No. of *N. fowleri*	
		Surface	Bottom	Surface	Bottom
10STP	20	4	8	0	0
1	16	2	5	0	0
3	20	6	8	1	1
4	20	7	8	1	0
4-1	20	8	8	0	1
5	20	6	6	2	2
6(a)	20	3	6	0	2
6(b)	20	2	1	0	0
7	20	0	4	0	0
8	20	2	2	1	0
9	20	1	6	0	0
10	20	2	3	0	0
10A	20	0	3	0	0
11	16	0	2	0	0
12	16	3	4	0	0
13	16	2	7	0	0
14	16	1	5	0	0
Totals	320	49	86	5	6
% of Samples	100	31	54	3.1	3.8

isolated from surface water and bottom sediment samples from all sites (Fig.2; Tables 3-7, appendix). Quality controls yielded positive cultures and amoebae caused pathology in mice during all sample periods (Tables 3-7, appendix).

A series of water samples from the Illinois Power Company discharge canal (site 10 STP) were sampled for amoebae during the period of August through September, 1988 (Fig.1, Table 8). A high percentage of thermophilic Naegleria sp. (10/12= 83%) were isolated but none was pathogenic to mice. The flume samples were analyzed separately because the high temperatures of the thermal effluent in the flume site 10STP were not representative of temperature conditions in Clinton Lake.

Naegleria fowleri from Clinton Lake was identified by comparison with known species of Naegleria (Table 9). All isolates of N. fowleri from Clinton Lake were identical in morphology, enflagellated at 37C, were thermotolerant at 45C in laboratory culture, and non-agglutinating in concanavalin-A. The DNA probe (RFLP) analysis was used to compare the DNA from the human Lee strain and Clinton Lake isolates of N. fowleri. The DNA bands separated by electrophoresis showed identical numbers and molecular weight in the ethidium bromide stained agarose gels. The high degree of homology (genetic similarity) between the Lee strain and Clinton Lake isolates provides strong evidence for the common identity of N. fowleri.

All pathogenic isolates from Clinton Lake were highly virulent and caused meningoencephalitis and death of mice in 3-7 days. The course of infection and symptoms shown by weanling Balb/C mice was similar to that of the control Lee strain of N. fowleri (Table 9).

DISCUSSION

A survey of Clinton Lake for the free-living amoeba Naegleria fowleri was conducted before and after the Clinton Power Station began production and release of heated effluent into the lake. A single N. fowleri isolate was collected in 1986, before the plant began production, demonstrating the presence of the free-living amoeba before temperature alteration (Table 1). In 1987 when the power station was being tested and heated effluent was intermittantly released, two N. fowleri isolates were collected at site 4, the point of entrance of the discharge canal. During 1988 when the power station was in full production and heated effluent was being continuously released, the number of N. fowleri isolates increased to 21. The increased occurrence of N. fowleri was associated with elevated water temperature during the months of June through October, 1988. N. fowleri was not isolated from the ambient temperature arm of the lake at any time during the study (Fig. 1, Table 1).

N. fowleri was isolated in comparable numbers from surface and bottom samples (Fig. 2). The amoeba was distributed throughout the water column and not confined to bottom sediments, as suggested by other studies (Wellings, 1977). It was not possible to determine which developmental stages of the amoeba (trophozoite, enflagellated, cyst) were present in water samples, but the enflagellated form is the known dispersal stage that is most probable to occur in surface waters (John, 1982).

Tyndall (1985) surveyed power plant cooling reservoirs throughout the United States and showed an increased prevalence of *N. fowleri* in thermally elevated cooling reservoirs. The present study verifies Tyndall's results, since most of the *N. fowleri* isolates were taken during months of 1986,1987 and 1988 when the maximum water temperatures in the heated arm were elevated in comparison with maximum water temperatures in the ambient arm (Fig. 2, Table 1). A single *N. fowleri* isolate in 1986 was collected during July; a warm summer month and high ambient water temperature period. The precise threshold temperature that selects for *N. fowleri* was not determined, and this problem will be examined through future research to be conducted at Clinton Lake.

It was expected that elevated temperatures in the cooling effluent that was passing through the flume would be selective for *N. fowleri*. A high percentage of thermophilic *Naegleria* sp. were isolated from the flume site 10 STP, but none were pathogenic *N. fowleri* (Table 8). Tyndall et al. (1989) studied the distribution of *N. fowleri* in a newly created cooling lake. He observed that *N. fowleri* was isolated only from heated lake water or sediment samples, but was not detected in source or discharge samples. Both of these studies suggest that a thermal optimum temperature is required to select pathogenic *N. fowleri*, and following selection, sustained high temperature may not provide optimum growth conditions for the amoeba. In laboratory experiments, *N. fowleri* was initially isolated from Clinton Lake water samples at an incubator temperature of 45C. However, the amoeba could not be maintained in continuous laboratory culture at 45C, and a cultivation temperature of 32-37C was required for laboratory culture. Future studies of the optimum threshold environmental temperatures that are required for the selection and growth of *N. fowleri* are needed.

TABLE 8. CLINTON AMOEBA SURVEY
ILLINOIS POWER STATION 10STP (Flume)

Sample Date	Temp. °C S*	B**	Amoeba Isol. 45C S_1	S_2	B_1	B_2	Amoeba Enflag. & Mouse Test	Mouse Path
16 August	46.2	42.4	-	+	$+^E$	+	B_1	0
30 August	35.7	35.2	-	$+^E$	+	+	S_1	0
20 September	33.7	31.5	$+^E$	$+^E$	$+^E$	+	S_1, S_2, B_1	0
20 October	26.3	22.6	-	-	-	$+^E$	B_2	0
19 December	11.7	11.6	-	-	$+^E$	-	B_1	0
		Total	1	3	4	4	7	

S*-surface, B**-bottom

....

TABLE 9. IDENTIFICATION OF *NAEGLERIA FOWLERI* FROM CLINTON LAKE BY COMPARISON WITH KNOWN *NAEGLERIA* SPECIES

IDENTIFICATION CRITERIA	KNOWN SPECIES			CLINTON LAKE ISOLATES
	N. gruberi	*N. australiensis*	*N. Fowleri* (LEE)	3S, 3B, 4S, 4B, 5S, 5B, 6B, 8S, 8B
ENFLAGELLATION	+20-25C	+ 37C	+ 37C	+ 37C
THERMOTOLERANCE IN CULTURE	< 37C	> 45C	> 45C	> 45C
CONCONAVALIN-A AGGLUTINATION	+	+	-	-
DNA HOMOLOGY WITH *N. FOWLERI* LEE STRAIN PROBE	NONE	NONE	HOMOLOGY	HOMOLOGY
PATHOLOGY IN WEANLING BALB-C MICE	NONE	VARIABLE PATHOLOGY DEATH IN 7-21 DAYS	ACUTE PATHOLOGY DEATH IN 3-7 DAYS	ACUTE PATHOLOGY DEATH IN 3-7 DAYS

LITERATURE CITED

De Jonckheere, J. and H. Van de Voorde. 1977. The distribution of Naegleria fowleri in man-made thermal waters. American Journal of Tropical Medicine and Hygiene. 26: 10-15.

Griffin, J.L. 1972. Temperature tolerance of pathogenic and non-pathogenic free-living amoebas. Science. 178: 869

Griffin, J.L. 1983. The pathogenic amoeboflagellate Naegleria fowleri: environmental isolations, competitors, ecological interactions and the flagellate-empty habitat hypothesis. J. Protozoology. 30: 403-409.

Huizinga ,H.W. 1988. Thermal ecology of Naegleria fowleri from a nuclear reactor cooling reservoir. Abstract of paper given at American Society of Parasitologists annual meeting, Wake Forest University.

Josephson, S.L., R.R. Weik and D.T. John. 1977. Concanavalin A induced agglutination of Naegleria. American Journal of Tropical Medicine and Hygiene. 26: 856.

John, D.T. 1982. Primary amebic meningoencecephalitis and the biology of Naegleria fowleri. Annual Reviews of Microbiology. 36: 101-123

John, D.T. and S.L.Nussbaum. 1983. Naegleria fowleri infection of mice through swimming in amoebae-contaminated water. J. Parasitology 69: 871-874.

Marciano-Cabral, F. 1988. Biology of Naegleria spp. Microbiological Reviews. 52: 114-132.

Martinez, A.J., E.C. Nelson, and R.J. Duma. 1973. Animal model: primary amebic (Naegleria) meningoencephalitis in mice. American J. of Pathology. 73: 545- 548.

McLaughlin, G.L., F.H. Brandt and G.S. Visvesvara. 1988. Restriction fragment length polymorphisms of the DNA of selected Naegleria and Acanthamoeba. J. Clinical Microbiology. 26: 1655-1658.

Page, F.C. 1967. Taxonomic criteria for limax amoebae, with Hartmanella and 3 of Vahlkampfia. J. Protozoology. 14: 499-521.

Page, F.C. 1976. Freshwater and soil amoebae. Freshwater Biological Association. Scientific Publication No. 34: 155pp

Reilly, M.F., F. Marciano-Cabral, D.W. Bradley, and S.G. Bradley. 1983. Agglutination of Naegleria fowleri and Naegleria gruberi by antibodies of human serum. J. Clinical Microbiology. 17: 576-581.

Tyndall, R.L. 1985. Pathogenic organisms in thermally altered reservoirs and other waters. In: Microbial Processes in Reservoirs. Ed. D. Gunnison. W. Junk Pub. 133-154.

Tyndall, R.L. and E.C. Dominique. 1983. Analysis of selected sites of the Illinois Power Company for the presence of free-living amoebae in August,1983. Technical Report, Illinois Power Co.

Tyndall, R.L., K.S. Ironside, P.L. Metler, E.L. Tan, T.C. Hazen, and C.B. Fliermans. 1989. Effect of thermal additions on the density and distribution of thermophilic amoebae and pathogenic Naegleria fowleri in a newly created cooling lake. Applied and Environmental Microbiology. 55: 722-732.

U.S. Nuclear Regulatory Commission Report. Office of Nuclear Reactor Regulation, Final Environmental Statement Related to the operation of the Clinton Power Station. Unit no. 1,Docket No. 50-461 NUREG-0854, May 1982.

Weik, R.R. and D.T. John. 1977. Agitated mass cultivation of Naegleria fowleri. J Parasitology. 63: 868-871.

Wellings, F. M., P.T. Amuso, S.L. Chang, and A.L. Lewis. 1977. Isolation and identification of pathogenic Naegleria from Florida lakes. Applied and Environmental Microbiology 34: 661-667.

Wellings, F.M. 1987. Survey of Clinton Lake for Naegleria fowleri. Report of research contract from Illinois Power Company.

APPENDIX

TABLE 3 CLINTON LAKE AMOEBA SURVEY SAMPLE DATE August 16, 1988

SITE NO.		WATER TEMP. C		AMOEBAE ISOLATED 45C				AMOEBAE ENFLAG. TESTED IN MICE	MOUSE PATHOGENS
H*	IP**	S*	B**	S1*	S2*	B1**	B2**		
1	17	31.7	30.2	-	-	+	+		
3	2	36.6	36.0	+	-	$+^E$	$+^E$	B_1, B_2	B_2
4	15	41.7	36.3	-	+	+	+		
4-1	2	39.1	32.3	+	+	+	+		
5	-	37.0	35.8	+	+	+	+		
6	13.2	33.8	33.4	-	+	$+^E$	$+^E$	B_1, B_2	B_2
	13.6	34.1	32.8	-	-	-	-		
7	-	33.3	30.8	-	-	+	-		
8	8.5	31.1	28.8	-	-	-	-		
9	-	33.2	30.8	-	-	+	$+^E$	B_2	
10	8	32.0	28.7	-	-	-	+		
10A	-	32.2	29.6	-	-	-	+		
11	-	31.7	31.1	-	-	-	$+^E$	B_2	
12	4	32.0	29.5	-	-	+	-		
13	-	32.6	29.9	-	-	+	+		
14	4.5	32.5	31.0	-	-	+	+		
Totals	$\bar{X}$	34.0	$\bar{X}$ 31.6	3	4	11	12	6B	2
CONTROLS:				1	2	3			
Clinton 8B2				$+^E$	$+^E$	$+^E$		3	3
N. fowleri Lee				$+^E$	$+^E$	$+^E$		3	3

S*-surface, B**-bottom, E-enflagellation
H*-Huizinga sites, IP**- Illinois Power Co. sites

TABLE 4 CLINTON LAKE AMOEBA SURVEY SAMPLE DATE August 30, 1988

SITE NO.		WATER TEMP.C		AMOEBA ISOLATED 45C				AMOEBAE ENFLAG. TESTED IN MICE	MOUSE PATHOGENS
H*	IP**	S*	B**	S1*	S2*	B1**	B2**		
1	17	19.3	19.0	+	-	-	+		
3	2	29.6	28.5	$+^E$	+	$+^E$	+	S_1, B_1	
4	15	34.8	33.5	+	+	-	+		
4-1	2	33.0	27.1	$+^E$	-	+	-	S_1	
5	-	30.3	30.3	+	-	-	+		
6	13.2	27.7	26.4	-	-	-	-		
	13.6	27.8	27.2	-	-	-	$+^E$	B_2	
7	-	25.6	25.2	-	-	-	+	S_1, B_2	
8	8.5	24.9	23.7	$+^E$	-	-	$+^E$	S_1, B_2	S_1
9	-	24.9	24.3	-	+	-	+		
10	8	25.1	24.3	-	-	-	$+^E$	B_2	
10A	-	24.7	23.8	-	-	+	$+^E$	B_2	
11	-	24.7	24.2	-	-	-	+		
12	4	24.8	24.3	+	-	-	+		
13	-	24.6	23.9	+	-	$+^E$	+	B_1	
14	4.5	21.3	20.6	+	-	-	$+^E$	B_2	
Totals	$\bar{X}$	26.4	$\bar{X}$ 25.4	9	3	4	14	4S, 8B	1
CONTROLS:				1	2	3			
Clinton 8B2				$+^E$	$+^E$	$+^E$		3	3
N.fowleri Lee				$+^E$	$+^E$	$+^E$		3	3

*S -surface,** B -bottom, E-enflagellation
*H- Huizinga sites,**IP -Illinois Power sites

TABLE 5 CLINTON LAKE AMOEBA SURVEY SAMPLE DATE September 20, 1988

SITE NO.		WATER TEMP. C		AMOEBAE ISOLATED 45C				AMOEBAE ENFLAG TESTED IN MICE	MOUSE PATHOGENS
H*	IP**	S*	B**	S1*	S2*	B1**	B2**		
1	17	16.7	17.0	-	$+^E$	+	+	S_2	
3	2	25.3	24.6	$+^E$	$+^E$	$+^E$	$+^E$	S_1, S_2, B_1, B_2	S_2
4	15	32.2	30.4	$+^E$	$+^E$	+	+	S_1, S_2	S_1
4-1	2	29.9	26.1	$+^E$	$+^E$	+	$+^E$	S_1, S_2, B_2	B_2
5	-	26.8	25.8	+	$+^E$	$+^E$	+	S_2, B_1	S_2, B_1
6	13.2	22.4	21.8	-	-	+	$+^E$	B_1, B_2	B_2
	13.6	23.3	22.3	+	-	-	-		
7	-	23.2	22.3	-	-	+	+		
8	8.5	22.6	22.0	$+^E$	-	-	-	S_1	
9	-	22.6	22.0	-	-	+	-		
10	8	22.5	21.4	$+^E$	$+^E$	-	+	S_1, S_2	
10A	-	22.6	21.9	-	-	-	-		
11	-	22.8	22.5	-	-	-	-		
12	4	22.1	21.3	+	+	+	+		
13	-	22.0	21.1	+	-	+	+		
14	4.5	18.7	18.9	-	-	$+^E$	-	B_1	
Totals	$\bar{X}$	23.4	$\bar{X}$ 21.3	9	7	11	10	11S, 6B	6
CONTROLS:				1	2	3			
Clinton 8B2				$+^E$	$+^E$	$+^E$		3	3
N.fowleri Lee				$+^E$	$+^E$	$+^E$		3	3

S*=surface, B**=bottom, E=enflagellation
H*=Huizinga sites, IP**= Illinois Power sites.

TABLE 6 CLINTON LAKE AMOEBA SURVEY SAMPLE DATE October 20, 1988

SITE NO.		WATER TEMP. C		AMOEBAE ISOLATED 45C				AMOEBAE ENFLAG. TESTED IN MICE	MOUSE PATHOGENS
H*	IP**	S*	B**	S1*	S2*	B1**	B2**		
1	17	11.2	10.4	-	-	-	-		
3	2	20.8	18.2	+	-	-	-		
4	15	25.8	21.0	+	+	+	-		
4-1	2	24.6	20.0	$+^{E}$	+	-	+	S_1	
5	-	22.2	18.4	-	$+^{E}$	-	$+^{E}$	S_2, B_2	S_2, B_2
6	13.2	19.1	15.5	$+^{E}$	$+^{E}$	-	+	S_1, S_2	
	13.6	19.8	17.0	-	$+^{E}$	-	-	S_2	
7	-	16.5	15.6	-	-	-	-		
8	8.5	16.3	15.1	-	-	+	-		
9	-	16.0	14.4	-	-	-	+		
10	8	15.8	14.0	-	-	-	-		
10A	-	15.6	14.5	-	-	-	-		
11	-	15.5	14.2	-	-	-	-		
12	4	15.3	13.6	-	-	-	-		
13	-	15.0	13.6	-	-	+	-		
14	4.5	12.2	11.7	-	-	+	-		
Totals		$\bar{X}$ 17.6	$\bar{X}$ 14.6	4	5	4	4	5S, 1B	2
CONTROLS:					1	2	3		
Clinton 8B2					$+^{E}$	$+^{E}$	$+^{E}$	3	3
N.fowleri Lee					$+^{E}$	$+^{E}$	$+^{E}$	3	3

S*=surface, B*=bottom, E=enflagellation
H*=Huizinga sites, IP**= Illinois Power sites

TABLE 7 CLINTON LAKE AMOEBA SURVEY SAMPLE DATE December 19, 1988

SITE NO.		WATER TEMP. C		AMOEBAE ISOLATED 45C				AMOEBAE ENFLAG. TESTED IN MICE	MOUSE PATHOGENS
H*	IP**	S*	B**	S1*	S2*	B1**	B2**		
1	17	N.D.							
3	2	6.1	6.2	-	-	$+^E$	+	B_1	
4	15	10.7	10.5	-	-	$+^E$	$+^E$	B_1, B_2	
4-1	2	7.8	7.9	-	+	+	+		
5	-	8.0	8.1	-	-	-	-		
6	13.2	6.5	6.7	-	-	-	+		
	13.6	6.6	6.8	-	-	-	-		
7	-	2.9	3.6	-	-	-	-		
8	8.5	2.2	2.8	-	-	-	-		
9	-	2.6	2.8	-	-	-	$+^E$	B_2	
10	8	2.2	3.0	-	-	-	-		
10A	-	2 0	2.6	-	-	-	-		
11	-	N.D.							
12	4	N.D.							
13	-	N.D.							
14	4.5	N.D.							
Totals	$\bar{X}$	5.2	$\bar{X}$ 5.5	T.0	1	3	5	4B	0
CONTROLS:					1	2	3		
Clinton 8B2					$+^E$	$+^E$	$+^E$	3	3
N.fowleri Lee					$+^E$	$+^E$	$+^E$	3	3

S*-surface, B**-bottom, E-enflagellation
H*-Huizinga sites, IP**-Illinois Power sites

Attachment B

Clinton Lake Water Temperature data

0-600768
L65-89(07-07)-LP
8D.150

ILLINOIS POWER COMPANY
500 SOUTH 27TH STREET, DECATUR, ILLINOIS 62525-1805

July 7, 1989

Mr. David Antonacci
Division of Environmental Health
Illinois Department of Public Health
535 W. Jefferson Street
Springfield, Illinois 62761

Dear Mr. Antonacci:

Clinton Lake Temperature Data

Enclosed are the Clinton Lake temperatures you requested in our meeting on June 22, 1989. These lake temperatures were taken by a DataSonde recorder at the public beach area and cover April to mid-May. Temperatures are retrieved from the recorder about every 45 to 60 days. We will transmit subsequent data to you as it becomes available.

Also enclosed is a copy of Dr. Tyndall's paper we discussed in the meeting. For more details on the antibodies, I would suggest the original work by Marciano-Cabral (reference #17).

If you need any other information, please call me at (217)424-6475.

Sincerely,

ILLINOIS POWER COMPANY

James A. Smithson
Supervisor - Field Biology

Encl.

JAS7:dmf

bc: D. P. Hall - V-275
R. Smith - A-16
D. L. Holtzscher - V-920
D. Waddell - V-920
J. L. Robinson/R. C. Thomas/Amoeba Monitoring File

Clinton Lake Water Temperatures

Main Beach 1989

Depth: .5m

Temperature Scale: ° Fahrenheit

DATE	Daily Mean	Weekly Mean
03/31/89	49.0	
04/01/89	48.4	
04/02/89	48.3	48.5
04/03/89	48.4	
04/04/89	48.7	
04/05/89	48.3	
04/06/89	48.9	
04/07/89	48.9	
04/08/89	48.1	
04/09/89	46.9	48.3
04/10/89	46.8	
04/11/89	46.7	
04/12/89	47.4	
04/13/89	48.4	
04/14/89	49.4	
04/15/89	50.8	
04/16/89	51.8	48.8
04/17/89	52.9	
04/18/89	52.4	
04/19/89	54.1	
04/20/89	55.1	
04/21/89	55.6	
04/22/89	56.4	
04/23/89	55.9	54.6
04/24/89	56.9	
04/25/89	60.5	
04/26/89	61.9	
04/27/89	63.1	
04/28/89	63.3	
04/29/89	63.3	
04/30/89	62.6	61.7
05/01/89	63.0	
05/02/89	60.9	
05/03/89	61.6	
05/04/89	60.6	
05/05/89	59.8	
05/06/89	58.0	
05/07/89	58.7	60.4
05/08/89	58.5	
05/09/89	57.7	
05/10/89	57.4	
05/11/89	57.6	
05/12/89	58.7	
05/13/89	60.0	
05/14/89	60.0	58.5
05/15/89	60.6	
05/16/89	61.3	

0-600-807
L-65-89(11-08)
8D.150

ILLINOIS POWER COMPANY

CLINTON POWER STATION, P.O. BOX 678, CLINTON, ILLINOIS 61727

November 8, 1989

Mr. David Antonacci
Division of Environmental Health
Ill. Dept. of Public Health
535 W. Jefferson Street
Springfield, IL 62761

Dear Mr. Antonacci:

Clinton Lake Temperature Data

In our July 11, 1989 meeting on Naegleria you indicated an interest in obtaining lake temperatures from the Clinton Lake Beach for the summer of 1989. Enclosed are the daily average temperatures from July 13 through October 4, 1989. With the temperatures previously sent to you, this should provide a complete daily record of lake temperatures from April through October 4.

Field collections have been completed for the 1989 Naegleria study on Clinton Lake. Dr. Huizinga is currently working on the laboratory analysis of samples collected this summer. I anticipate we should have a draft of the results early next year. We will keep you informed of our results when they become available.

If you have any questions or need additional information, please feel free to call me at (217) 424-6475.

Sincerely,

James A. Smithson
Supervisor
Field Biology

JAS/gw
Enclosure

bcc: D. P. Hall, V-275
D. L. Holtzscher/W. Iliff, V-920
J. E. McDonald, A-16
J. L. Robinson/R. C. Thomas/Amoeba
Correspondence File, A-17

Clinton Lake Water Temperatures

Main Beach 1989

Depth: .5m

Temperature Scale: ° Fahrenheit

DATE	Daily Mean	Weekly Mean
07/13/89	87.4	
07/14/89	84.9	
07/15/89	83.6	
07/16/89	81.8	86.3
07/17/89	82.7	
07/18/89	80.3	
07/19/89	79.4	
07/20/89	77.6	
07/21/89	76.8	
07/22/89	77.3	
07/23/89	77.7	78.8
07/24/89	79.1	
07/25/89	80.4	
07/26/89	82.8	
07/27/89	82.4	
07/28/89	82.6	
07/29/89	83.1	
07/30/89	82.9	81.9
07/31/89	83.4	
08/01/89	83.4	
08/02/89	84.1	
08/03/89	82.9	
08/04/89	82.9	
08/05/89	83.4	
08/06/89	81.9	83.2
08/07/89	79.7	
08/08/89	79.9	
08/09/89	79.1	
08/10/89	80.3	
08/11/89	80.6	
08/12/89	81.0	
08/13/89	82.7	80.5
08/14/89	83.5	
08/15/89	84.7	
08/16/89	83.9	
08/17/89	82.4	
08/18/89	81.8	
08/19/89	82.4	
08/20/89	81.0	82.8
08/21/89	83.4	
08/22/89	83.5	
08/23/89	84.1	
08/24/89	82.7	
08/25/89	82.9	
08/26/89	83.5	
08/27/89	83.7	83.4
08/28/89	82.5	

10/10/89

Clinton Lake Water Temperatures

Main Beach 1989

Depth: .5m

Temperature Scale: ° Fahrenheit

DATE	Daily Mean	Weekly Mean
08/29/89	81.2	
08/30/89	83.7	
08/31/89	82.9	
09/01/89	81.5	
09/02/89	81.8	
09/03/89	82.1	82.3
09/04/89	81.7	
09/05/89	82.4	
09/06/89	81.5	
09/07/89	82.5	
09/08/89	83.2	
09/09/89	80.9	
09/10/89	81.3	81.9
09/11/89	80.8	
09/12/89	78.9	
09/13/89	75.2	
09/14/89	73.4	
09/15/89	73.7	
09/16/89	75.2	
09/17/89	77.2	76.4
09/18/89	76.2	
09/19/89	75.7	
09/20/89	76.2	
09/21/89	77.1	
09/22/89	76.5	
09/23/89	72.6	
09/24/89	73.2	75.4
09/25/89	73.1	
09/26/89	71.2	
09/27/89	70.9	
09/28/89	71.8	
09/29/89	70.8	
09/30/89	72.0	
10/01/89	72.5	71.8
10/02/89	71.4	
10/03/89	70.9	
10/04/89	71.0	

Attachment C

Biological Report

CLINTON POWER STATION

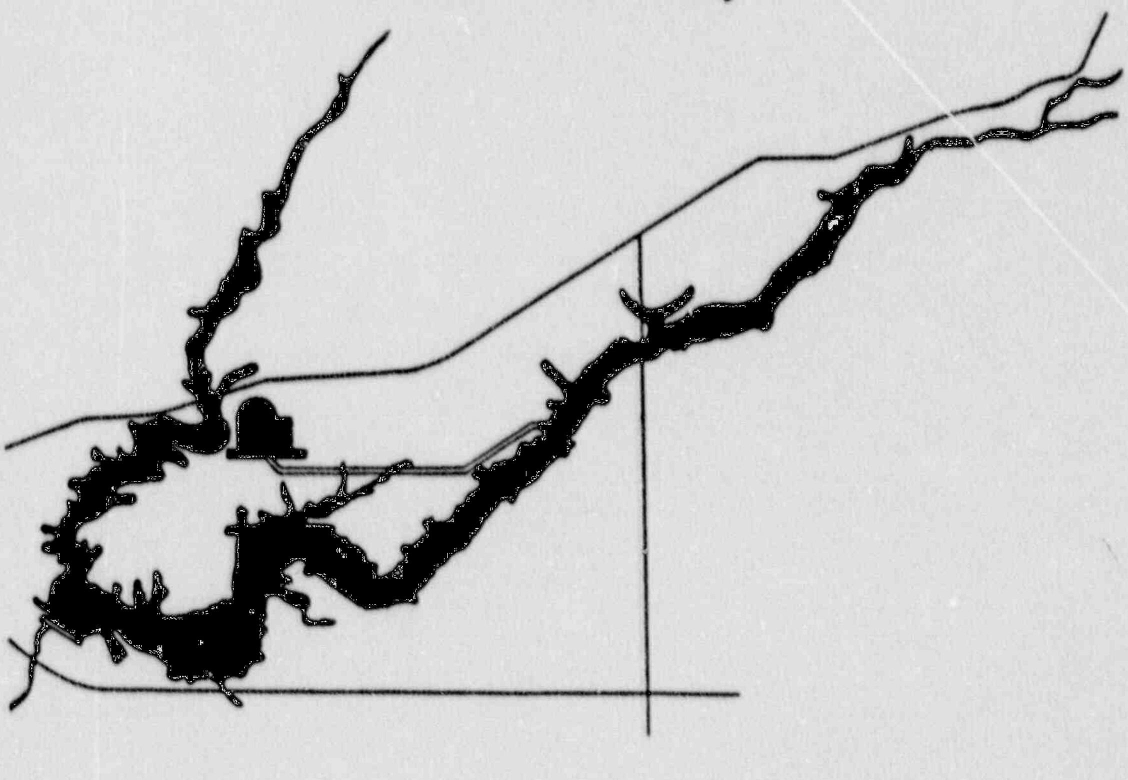
Environmental Monitoring Program

BIOLOGICAL REPORT

Comparison of Preoperational Data (1983-1986)

with Operational Data (1987-1988)

Executive Summary



prepared by
ILLINOIS POWER
Environmental Affairs Dept.
Field Biology Laboratory
1989

TABLE OF CONTENTS

Preface

This report analyzed the biological portion of the Clinton Power Station, Environmental Monitoring Program (EMP) during the first two operational years and compared it with the last four preoperational years. The biological portion of the EMP was conducted by the Field Biology Section of the Environmental Affairs Department of Illinois Power Company. This report is divided into six chapters covering each of the biological disciplines sampled and lake temperatures. Each chapter was authored by the person responsible for that discipline. Authors for chapters are as follows:

Periphyton	Ronald L. Willmore
Phytoplankton	Ronald L. Willmore
Zooplankton	John M. Burke
Benthos	John M. Burke
Fisheries	M. Stephen Pallo
Temperature	David W. Plunkett

The report was edited by James A. Smithson and typed by Gretchen S. Williamson.

EXECUTIVE SUMMARY
Clinton Power Station
Environmental Monitoring Program
Biological Report
Comparison of Preoperational Data (1983-1986)
with Operational Data (1987-1988)

Illinois Power Company implemented the Environmental Monitoring Program (EMP) to satisfy various permits and licenses. The EMP assesses the effects of construction and operation of the Clinton Power Station (CPS) on the aquatic communities in Clinton Lake. The EMP Preoperational Biological Report discussed the effects from lake filling (May 1978) to the end of the preoperational period (December 1986). The purpose of this report is to assess the effects of the first two years of CPS operations (1987 and 1988) on aquatic communities in Clinton Lake and Salt Creek downstream of the lake. This assessment analyzed 1987 and 1988 biological data and compared it to the last four years of preoperational data (1983-1986).

Lake Temperatures

The primary purpose of Clinton Lake is to provide cooling water for CPS. As such, CPS thermal discharges represent the major operational effect on aquatic communities in Clinton Lake. Lake temperatures were monitored from 1986 through 1988. Thermal discharges during most of 1987 remained relatively low as the CPS progressed through power ascension testing. Thermal discharges in 1988 were the result of full power operation.

Thermal discharges to the lake were typically 18°F (10°C) higher than plant intake temperatures. Clinton Lake effectively dissipated the heat and temperatures returned to within 0.5°F (0.3°C) of intake temperatures half way through the cooling loop. Lake temperatures were influenced more by meteorological conditions than by plant operations at all sites, except in the immediate area of the thermal discharge.

Discharges from Clinton Lake to Salt Creek in the summer of 1988 were well below the State Water Quality temperature limits and CPS did not appear to have any thermal influence on Salt Creek.

Periphyton

Periphyton is the algae which forms a slippery brown or green layer on rocks, logs, and other substrata in lakes and streams. Diatoms, green algae, and blue-green algae comprised most of the periphyton in Salt Creek, downstream from Clinton Lake. Diatoms comprised 75-98% of the community. Periphyton densities increased slightly during operational years, while chlorophyll a concentrations decreased. Changes in the periphyton community were more likely associated with unusually warm summers and drought conditions than from CPS operations.

Phytoplankton

Phytoplankton is the plant portion of the plankton community which, through photosynthesis, provides the primary energy source for aquatic ecosystems. Diatoms and green algae comprised the majority of phytoplankton in Clinton Lake. Shifts in dominant groups from diatoms to green algae occurred through the years, particularly during operational years.

Seasonal densities of major groups were similar to other reservoirs. During operational years, densities, primary productivity, and chlorophyll a concentrations increased at all lake sites, except near the discharge canal. In operational years, primary productivity was reduced near the discharge canal during the summer months when CPS discharge water temperatures were greater than 25°C. This reduction was temporary and photosynthesis was restored when the discharge plume reached approximately one third of the way around the cooling loop. During the spring and fall when temperatures were cooler, primary productivity increased near the discharge canal due to warmer water temperatures.

Phytoplankton in Salt Creek, downstream from Clinton Lake, was similar to the lake in composition and shifts of the dominant groups in operational years. Mean species diversity increased in Salt Creek during operational years and was slightly higher than the lake sites.

Zooplankton

Zooplankton are the animal portion of the plankton community in lakes and streams. Rotifera, Copepoda, and Cladocera were the dominant groups in both Clinton Lake and Salt Creek, and in both preoperational and operational years. Several changes in dominant zooplankton taxa in operational years were noted. In Clinton Lake, abundance increased for several rotifer taxa, immature calanoid copepods, and one cladoceran taxa. Seasonal taxa changes included increased spring abundance of some rotifers, decreased fall abundance of other rotifers, and increased summer abundance of immature cyclopoid copepods. Only one rotifer taxa was less abundant in all seasons of operational years.

In Clinton Lake, zooplankton taxa numbers, densities, and diversities all changed slightly from preoperational to operational years. Taxa numbers in fall were lower in operational years than in preoperational years. The typical seasonal flux in taxa number tended to level off in operational years at the site closest to the discharge. Taxa numbers tended to decrease, while densities increased, as distance from the thermal discharge increased. The seasonal peak zooplankton diversities shifted from summer in preoperational years to spring in operational years.

Many of the changes in the zooplankton community during operational years may have been related to drought conditions which existed in those years. Continued sampling should clarify which changes were related to meteorological conditions and which were related to CPS operations.

Several changes were noted in the zooplankton community in Salt Creek from 1983 through 1988. These changes, however, appeared to be part of the natural variability typical of stream communities and not related to CPS operations.

Benthos

Benthic macroinvertebrates (benthos) are those organisms which live on, in, or near the bottom substrate in lakes and streams. Clinton Lake and Salt Creek benthic communities were dominated by midges and worms, in both preoperational and operational years. Few consistent preoperational/

operational changes were noted in the Clinton Lake benthos. Most of the changes were within the natural variation seen in preoperational years. Some changes, however, appeared to be related to CPS operations.

In Clinton Lake during operational years, abundance of only one midge taxa was reduced lakewide. Abundance of two other midge taxa were reduced near the thermal discharge. Benthos taxa numbers and densities increased in winter and spring but decreased in summer and fall. This was most evident in the summer of 1988 at the end of the discharge canal where only one species, Chaoborus punctipennis was collected.

Asiatic clam (Corbicula) abundance increased since they were first collected in 1986. These clams have the potential to invade CPS water systems and cause fouling problems.

No consistent differences were noted between preoperational and operational years in the benthic macroinvertebrate community of Salt Creek.

Fisheries

Gizzard shad, common carp, white crappie, bluegill, largemouth bass, quillback, and bigmouth buffalo were the most common fish in Clinton Lake. Walleye, tiger muskellunge, and hybrid striped bass populations were established and maintained by stockings. These species adapted to the lake and diversified the recreational fishery. Largemouth bass and walleye populations were supplemented with stockings from on-site rearing ponds.

During CPS operation abundance, biomass, growth, condition, year class strength, and population structure improved for most of the major sport fishes. Abundance and biomass increased for white crappie, largemouth bass, bluegill, and hybrid striped bass. Growth increased considerably (52%) for young largemouth bass. Growth also increased for several age groups of white crappie, largemouth bass, walleye, and hybrid striped bass. Condition of all major species was good with improvements for white crappie, bluegill, walleye, and common carp. Young largemouth bass had the greatest improvement in year class strength (350%). Hybrid striped bass, white crappie, and gizzard shad also showed improvements in year class strength during operational years. Population structure also improved for white crappie, largemouth bass, and walleye.

Several species were attracted to the warm discharge waters in cold months and temporarily avoided the warm discharge waters during summer months. Gizzard shad were the dominant prey for game fishes. External parasites and abnormalities were encountered infrequently.

The stream communities were dominated by common minnow species. Thermal impacts were not evident in the stream and no major changes were observed. A limited sports fishery for hybrid striped bass and walleye which escaped from Clinton Lake exists below the dam, especially during high water flows.

operational changes were noted in the Clinton Lake benthos. Most of the changes were within the natural variation seen in preoperational years. Some changes, however, appeared to be related to CPS operations.

In Clinton Lake during operational years, abundance of only one midge taxa was reduced lakewide. Abundance of two other midge taxa were reduced near the thermal discharge. Benthos taxa numbers and densities increased in winter and spring but decreased in summer and fall. This was most evident in the summer of 1988 at the end of the discharge canal where only one species, Chaoborus punctipennis was collected.

Asiatic clam (Corbicula) abundance increased since they were first collected in 1986. These clams have the potential to invade CPS water systems and cause fouling problems.

No consistent differences were noted between preoperational and operational years in the benthic macroinvertebrate community of Salt Creek.

Fisheries

Gizzard shad, common carp, white crappie, bluegill, largemouth bass, quillback, and bigmouth buffalo were the most common fish in Clinton Lake. Walleye, tiger muskellunge, and hybrid striped bass populations were established and maintained by stockings. These species adapted to the lake and diversified the recreational fishery. Largemouth bass and walleye populations were supplemented with stockings from on-site rearing ponds.

During CPS operation abundance, biomass, growth, condition, year class strength, and population structure improved for most of the major sport fishes. Abundance and biomass increased for white crappie, largemouth bass, bluegill, and hybrid striped bass. Growth increased considerably (52%) for young largemouth bass. Growth also increased for several age groups of white crappie, largemouth bass, walleye, and hybrid striped bass. Condition of all major species was good with improvements for white crappie, bluegill, walleye, and common carp. Young largemouth bass had the greatest improvement in year class strength (350%). Hybrid striped bass, white crappie, and gizzard shad also showed improvements in year class strength during operational years. Population structure also improved for white crappie, largemouth bass, and walleye.

Several species were attracted to the warm discharge waters in cold months and temporarily avoided the warm discharge waters during summer months. Gizzard shad were the dominant prey for game fishes. External parasites and abnormalities were encountered infrequently.

The stream communities were dominated by common minnow species. Thermal impacts were not evident in the stream and no major changes were observed. A limited sports fishery for hybrid striped bass and walleye which escaped from Clinton Lake exists below the dam, especially during high water flows.

INTRODUCTION

Purpose and Scope of Monitoring Program

An Environmental Monitoring Program (EMP) was implemented by Illinois Power Company to satisfy requirements of various permits and licenses related to the effects of construction and operation of the Clinton Power Station (CPS). Numerous reports have been generated which analyzed the results of monitoring efforts during preconstruction, construction, and the preoperational periods for the EMP (Table 1). The purpose of this report is to assess the effects of the first two years (1987 and 1988) of CPS operations on the aquatic communities in Clinton Lake and Salt Creek downstream of the lake. This assessment analyzed the 1987 and 1988 biological data and compared it with the last four years of the preoperational data (1983-1986).

The basic monitoring design was unchanged from the preoperational period and consisted of periodic, quantitative sample collections from sites in Clinton Lake and Salt Creek. These sites were previously selected to represent varying amounts of influence from CPS operations. The aquatic communities encompassed in the monitoring program included periphyton, phytoplankton, zooplankton, benthic macroinvertebrates, and fish. The major focus of the analyses was to determine if CPS operations had any effects on abundance, seasonal patterns, distribution, or community structure of these aquatic communities. The specific study methods, results, and discussions for each aquatic community are presented in their respective chapters.

Table 1 Chronological synopsis of reports which contain environmental data pertinent to the Clinton Power Station, Clinton, Illinois.

Illinois Power Company. 1973. "Clinton Power Station Units 1 and 2. Applicants Environmental report, Construction Permit State", Vols. 1 through 4 and Supplements. Docket Nos. 50-461 and 50-462, Oct. 26, 1973.

United States Atomic Energy Commission. 1974. Final Environmental Statement Related to the Proposed Clinton Power Station Units 1 and 2. Illinois Power Company, Docket Nos. 50-461 and 50-462.

Industrial Bio-Test Laboratories, Inc. 1975. Clinton Preconstruction Environmental Monitoring May 1974 through April 1975. Annual Report to Sargent and Lundy Engineers. Chicago, Illinois.

_____ 1976. Clinton Preconstruction Environmental Monitoring May 1975 through April 1976. Annual Report to Sargent and Lundy Engineers. Chicago, Illinois.

_____ 1977. Environmental Monitoring May 1976 through April 1977 Construction Phase Clinton Power Station. Annual Report to Sargent and Lundy Engineers. Chicago, Illinois.

_____ 1978. Environmental Monitoring May 1977 through April 1978 Construction Phase Clinton Power Station. Annual Report to Sargent and Lundy Engineers. Chicago, Illinois.

Illinois Power Company. 1979. Clinton Power Station Units 1 and 2. Environmental Report Operating License State.

Energy Impact Associates. 1980. Thermal Demonstration Pursuant to Illinois Pollution Control Board Rules and Regulations Chapter 3, Rule 203(i)(10). Prepared for Illinois Power Company, Clinton Power Station Unit 1. P. O. Box 1899, Pittsburgh, Pennsylvania 15230.

Illinois Power Company. 1982. Clinton Power Station Environmental Monitoring Program. Biological Report May 1978-November 1980 Volumes 1-4. Environmental Affairs Department Field Biology Laboratory, Decatur, Illinois.

U. S. Nuclear Regulatory Commission. 1982. Final Environmental Statement Related to the Operation of the Clinton Power Station, Unit No. 1. Illinois Power Company et. al.

Kurzawski, K. F. 1984. Clinton Lake Creek Survey 1982-1983. Illinois Power Company, Decatur, Illinois.

Illinois Power Company. 1985. Clinton Power Station Environmental Monitoring Program. Biological Report 1981-1983. Volumes 1-4. Environmental Affairs Department Field Biology Laboratory, Decatur, Illinois.

Table 1 (Continued)

_____ 1986. Clinton Lake Preoperational Environmental Monitoring Program. Water Quality Report. Environmental Affairs Department, Decatur, Illinois.

_____ 1987. Clinton Power Station Environmental Monitoring Program Preoperational Biological Report. 1978-1986. Volumes 1-7. Environmental Affairs Department Field Biology Laboratory, Decatur, Illinois.

_____ 1989. Clinton Power Station Hydrothermal Modeling and Environmental Impact Assessment Studies for an amended Petition for Variance. Environmental Affairs Department, Decatur, Illinois.

_____ 1989. Clinton Power Station Environmental Monitoring Program Water Quality Report. January 1978 through December 1988. Environmental Affairs Department, Decatur, Illinois.

Pallo, M. S. 1988. Clinton Power Station Fish Impingement Report April 1987-May 1988. Illinois Power Company, Environmental Affairs Department, Decatur, Illinois.

_____ 1988. Clinton Lake Creek Survey 1981-1986. Illinois Power Company, Environmental Affairs Department, Decatur, Illinois.

Description of Environs and Clinton Power Station

The Clinton Power Station is located in DeWitt County approximately 9.6 km (6 miles) east of Clinton and 96 km (60 miles) northeast of Springfield (Figure 1). The CPS is a 950 MW nuclear-fueled, electric generating station which utilizes a once-through cooling system. Circulating water is withdrawn from the North Fork arm of Clinton Lake, passes through the CPS condenser, flows through a 5.0 km (3.1 miles) discharge flume, and is discharged to the Salt Creek arm of the lake (Figure 1). The CPS nuclear reactor reached initial criticality on February 27, 1987. Power ascension testing began in April and continued into September of 1987. The warranty run of 100% power for 100 hours was completed on October 9, 1987. The CPS was in full operation throughout 1988, with the exception of a long outage in April.

Clinton Lake is a 1,981 ha (4,895 a) impoundment which was built to provide cooling water for the CPS (Table 2). The lake was formed by an earthen dam constructed 366 m (400 yd) downstream from the confluence of Salt Creek and the North Fork. Dam construction was completed October 12, 1977, and Clinton Lake reached normal pool elevation, which is 210 m (690 feet) (Table 2) on May 17, 1978. The inundated valleys of the North Fork and Salt Creek resulted in an impoundment which is roughly V-shaped. The North Fork arm of the lake extends about 13 km (8 miles) and the Salt Creek arm 25.6 km (16 miles) from the dam. Clinton Lake has a storage capacity of $9.15 \times 10^7 m^3$ (74,200 acre feet) and an average depth of 4.6 m (15.2 feet). Most of the 209 km (130 miles) of shoreline is wooded. The valleys of the North Fork and Salt Creek were extensively wooded. Timber within the main lake basin was removed prior to lake filling, however, most of the vegetation was left intact in areas which became large coves.

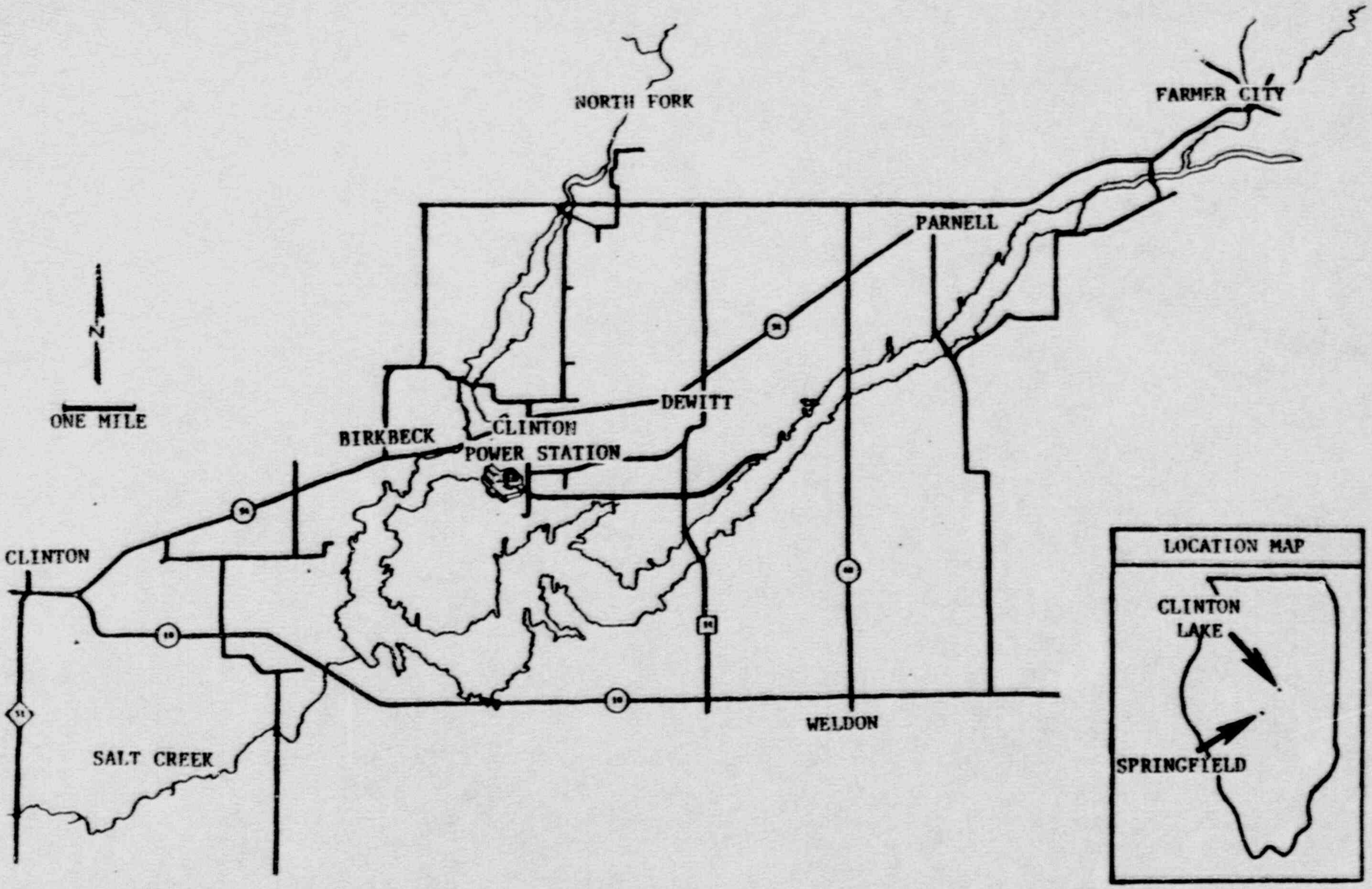


Figure 1. Map of Clinton Lake, DeWitt County, Illinois.

Table 2 Selected hydrological features of Clinton Lake, near Clinton, Illinois.

Parameter	Metric	English
Surface area	1,981 ha	4,895 a
Average depth	4.6 m	15.2 ft
Maximum depth	13.7 m	45 ft
Shoreline depth	209 km	130 mi
Storage capacity	$9.15 \times 10^7 m^3$	74,200 acre-ft
Watershed	766.6 km^2	296 mi^2
Shoreline development	13.2*	13.2*
Normal pool elevation	210 m	690 ft
Length of North Fork arm	12.8 km	8 mi
Length of Salt Creek arm	25.6 km	16 mi

*Number represents an index without units

Clinton Lake and much of the surrounding land is leased to the Illinois Department of Conservation (IDOC). The IDOC has opened the area to the public for many recreational activities such as fishing, hunting, swimming, hiking, cross-country skiing, camping, and boating. Fishing and the associated fisheries management program have effected the development of the aquatic communities in Clinton Lake. The sport fishery is managed in part by supplemental stockings of native and experimental fish species. Information from the EMP has been, and will continue to be, useful in the evaluation of the fisheries management programs.

Attachment D

Water Quality Report

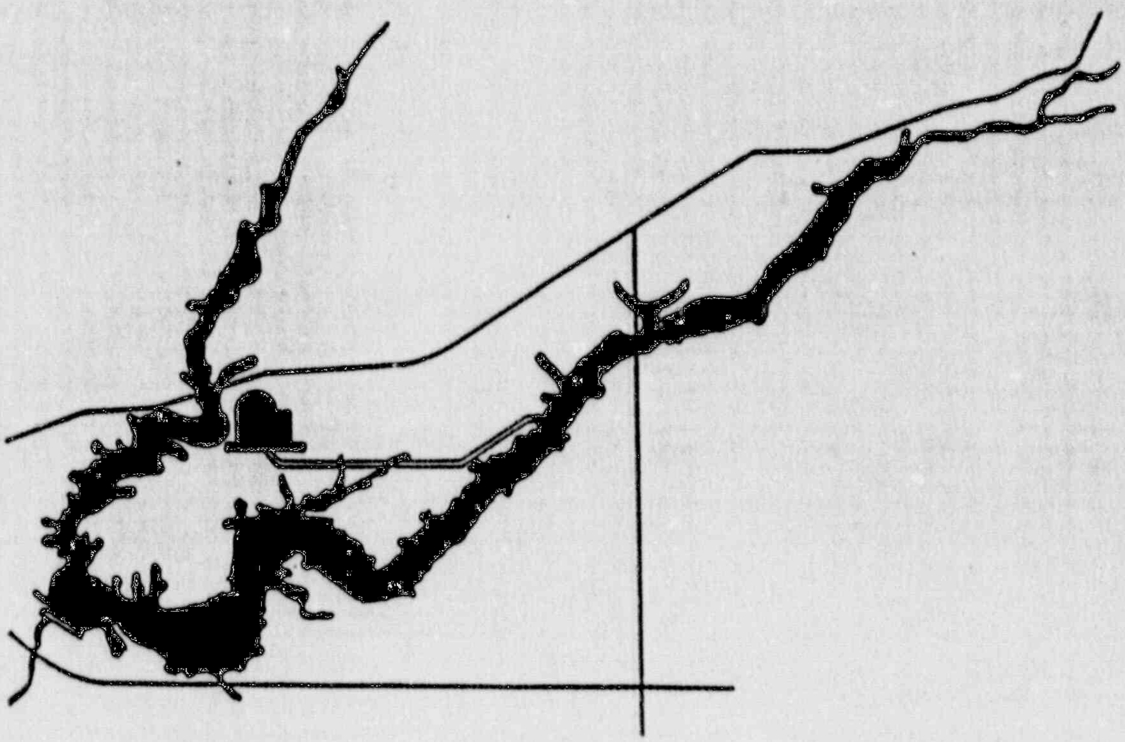
CLINTON POWER STATION

Environmental Monitoring Program

WATER QUALITY REPORT

January 1978 through December 1988

Volume 1



prepared by
ILLINOIS POWER
Environmental Affairs Dept.
1989

5.0 EXECUTIVE SUMMARY

Clinton Lake was constructed in 1978 to provide cooling water for the Clinton Power Station (CPS). Since then, Illinois Power Company has monitored the water quality of Clinton Lake to satisfy various environmental regulations, licenses, and permits associated with the construction and operation of CPS. Twenty-eight water quality constituents were monitored during 1978 through 1988. CPS began operation on February 27, 1987.

One goal of this report was to determine the temporal and spatial variability of water quality data for Clinton Lake during the period prior to CPS operation. This water quality database provides the foundation for assessments of potential effects of CPS operations. Another goal of this report was to assess what effects the initial two years of CPS operations (1987 and 1988) had on the water quality of Clinton Lake.

Clinton Lake water quality data are similar to other Illinois lakes and there were no unusual patterns in the distributions of data for any of the water quality constituents. Cluster analyses of a matrix of similarity indices for 13 other Illinois lakes indicated that Clinton Lake was most similar to nearby lakes Bloomington and Decatur.

Data for six constituents were not within IPCB General Use water quality standards for one or more samples during 1978 through 1988. Total phosphorus exceedences occurred for 70% of the epilimnion samples.

in Clinton Lake. High concentrations of phosphorus in Clinton Lake are probably due to surface water runoff from adjacent agricultural land. Exceedences of the IPCB General Use water quality standard for total phosphorus were reported in 62% of the lakes and reservoirs in Illinois.

Four water quality constituents (pH, nitrate, mercury, and fecal coliforms) had exceedences only during the period prior to CPS operation. Only one exceedence occurred for pH in epilimnion samples collected from 1978 through 1988. Six nitrate samples (1%) exceeded the IPCB standard during 1978 through 1988. Mercury concentrations exceeded the standard in 25 epilimnion samples (6%) prior to 1984. Exceedences of mercury are attributed to sampling or analytical errors. This conclusion was supported by: inconsistent results among strata and among preceding and succeeding sampling events; exceedences have not occurred in samples collected since 1984; and results of mercury analyses of fish flesh and sediments do not document a mercury problem in Clinton Lake. Fecal coliform counts exceeded the IPCB standard in 14 samples (4%) collected from 1978 through 1986. Ratios of fecal coliform:fecal streptococcus suggest fecal contamination is not from human sources. Samples were not analyzed for fecal coliform during 1987 and 1988.

Metalimnion and hypolimnion dissolved oxygen concentrations were below the IPCB standard (5 mg/l) during the preoperational and operational periods. Most Illinois lakes cannot meet the standard in bottom waters during summer. Dissolved oxygen concentrations were significantly (95% confidence) lower during the period when CPS was operational. One percent of the epilimnion dissolved oxygen concentrations were less than the standard during the preoperational period and 8% were less than the standard during the operational period. The increased percentage of epilimnion samples with dissolved oxygen concentrations less than the standard during the operational period was apparently due to increased water temperatures.

Carlson's Trophic State Index (TSI) values indicate Clinton Lake is eutrophic (highly productive). The mean TSI (64.6) for Clinton Lake is similar to the mean TSI for 69 other Illinois lakes (65.2). Comparisons of TSI values for Secchi transparency, total phosphorus and chlorophyll *a* indicate algal production in Clinton Lake may be limited due to light attenuation from suspended inorganic materials (silt and clay). Increased water temperatures in Clinton Lake due to CPS operation apparently have not affected the trophic status since the TSI values during operational years were within the range of TSIs during preoperational years.

Analysis of variance indicate there were six water quality constituents which had significant (95% confidence) differences between preoperational and operational periods. Three of these constituents, temperature, sulfate, and chloride, had increasing trends and the other three constituents, dissolved oxygen, nitrate, and silica had decreasing trends.

Water temperatures were significantly (95% confidence) greater during the period when CPS was operational. Temperature is the most important variable in the assessment of CPS-induced limnological changes to Clinton Lake. In general, Clinton Lake does not develop the stable, long-term thermal stratification. Distinct long-term stratification did not develop even at Site 8, the deepest site and the site where stratification was most expected. Any tendency for CPS operations to induce thermal stratification appeared to be limited to Site 2, which is closest to the discharge canal. Temperatures during operational conditions indicate the greatest temperature range among sites was 9.1 C.

Increased sulfate concentrations were attributed to low water levels in Clinton Lake during the operational period. Unusually hot and dry meteorological conditions in 1988 (second lowest rainfall in 110 years) contributed to low water levels in Clinton Lake. The lower lake levels concentrated sulfates and may have increased the oxidation of sulfides which had previously been entrained in anaerobic sediments at greater depths. Increased oxidation occurred due to mixing from wind and CPS operations.

Decreased nitrate concentrations were attributed to greater concentrations of phytoplankton which depleted nitrate supplies, and to low precipitation in 1988.

Decreased silica concentrations were attributed to an artifact of changes in sample collection schedules between periods, and concomitant shifts in diatom population densities. Usage of silica by diatoms can greatly modify flux rates of silica in lakes.

Chloride concentrations were significantly greater during the period when CPS was operational. Increased chloride levels were at least partially due to concentration from evaporative loss. Sodium hypochlorite is used to treat the condenser cooling water system of CPS. However, the cumulative dosage used in these treatments could account for only 1% of the increase in chloride concentrations in Clinton Lake during the period when CPS was operational.

Water quality data from Clinton Lake are similar to several other central Illinois reservoirs. Influences of CPS operations are primarily associated with increased water temperatures and concomitant decreased dissolved oxygen concentrations. These effects are predominately restricted to the area near the CPS cooling water discharge flume.

Assessments of CPS influences should be considered preliminary. Only two years of operational data have been collected, and data collected in 1988 were influenced by the unusually hot and dry meteorological conditions (second driest year on record in 110 years). Thus, the limnological changes in Clinton Lake due to CPS operations are probably overstated for years with more normal meteorological conditions. Continued monitoring of water quality constituents in Clinton Lake should provide a better assessment of limnological effects of CPS operations.