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Aquatic Impacts from Operation of Three Midwestern Nuclear Power Stations

Cooper Nuclear Station
Environmental Appraisal Report

Prepared by J. R. Brice

Environmental Science and Engineering, Inc.

Prepared for
U.S. Nuclear Regulatory
Commission

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ABSTRACT

Cooper Nuclear Station is located on the Nebraska side of the Missouri River in Nemaha County. The station utilizes a boiling water reactor and steam turbine generator to produce 778 MW (net) of electrical power. The cooling system is a once-through design that withdraws water from, and discharges to, the Missouri River.

No significant adverse impacts to the biota of the Missouri River from Cooper Nuclear Station discharge were detected. Localized effects in the vicinity of the discharge have been observed. These include changes in the diversity and productivity of phytoplankton, periphyton, and benthic invertebrates at certain times of the year.

The station appears to entrain large numbers of catostomid larvae, but this loss is not reflected in the available commercial fisheries statistics. Large numbers of gizzard shad and freshwater drum are impinged annually by Cooper Nuclear Station, but neither of these species seem to be adversely affected. Bigmouth buffalo populations could potentially suffer losses, but as was the case with the other catostomids, commercial catches of bigmouth buffalo did not seem to be affected by station operation.

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SUMMARY OF FINDINGS

SUMMARY OF FINDINGS

Cooper Nuclear Station is located on the Nebraska side of the Missouri River at River Mile (RM) 532.5. The station utilizes a boiling water reactor and steam turbine generator to produce 778 MW (net) of electrical power. The cooling system is a once-through design that withdraws water from, and discharges to, the Missouri River. When the plant is operating at full load, the heat rejection rate is 5.6 X 10^9 BTU/hour.

Cooper Nuclear Station does not alter the phytoplankton, periphyton, zooplankton, or benthic macroinvertebrate communities of the Missouri River. Some effects were noted for these groups but they were confined to either minor seasonal differences or were spatially limited. For example, pytoplankton studies indicated that initial (7 hour) effects usually included slight stimulation during the winter and minor inhibition of productivity during the remainder of the year. There was also some evidence of a shift in community composition in samples collected from the discharge canal. These changes, at times, favored the more tolerant green and blue-green algae over the diatoms but were not consistent enough, or of sufficient magnitude, to demonstrate major plant-related effects.

Cooper Nuclear Station entrained an estimated 0.9 to 6.5 percent of the river zooplankton annually from 1974 through 1977. This calculation was based on plant water usage and the assumption of zooplankton homogeneity in the Missouri River.[16]

As an average through time (4 years), the plant entrained 2.9 percent of the river zooplankton. This grand mean, however, is probably low since during 1977 there was a trend toward greater water usage as the station operated at higher turbine capacity (>84 percent on 8 of 12 sampling periods).[12] Thus, an average calculated for 1977 only, indicated that 3.7 percent of the river zooplankton was entrained by Cooper Nuclear Station. This may represent a worst case situation.

No significant adverse impacts to the biota of the Missouri River from the Cooper Nuclear Station discharge were detected. Localized effects in the vicinity of the discharge have been observed. These include changes in the diversity and productivity of phytoplankton, periphyton, and benthic invertebrates at a certain time of the year. The plant neither enhances the fisheries of the Missouri River nor does it provide good winter fisheries such as those reported elsewhere.

The station appears to entrain large numbers of catostomid larvae by entrainment but this loss is not reflected in the available commercial fisheries statistics. Large numbers of gizzard shad and freshwater drum are impinged annually by the Cooper Nuclear Station, but neither of these species seem to be adversely affected. Bigmouth buffalo populations could potentially suffer losses, but as was the case with the other catostomids, commercial catches of bigmouth buffalo did not seem to be affected by station operation.

Cooper Nuclear Station does not interrupt fish movement in the Missouri River, and the plume does not form a blockade. Tagging studies conducted near Cooper and Fort Calhoun Nuclear Stations indicated random movement, with no apparent trends. Other studies have also indicated that fish will move in and out of thermal plumes.

Inspection of the data for the October to November period suggested that gizzard shad, carp, and (to a lesser extent) goldeye were the species that would most likely be affected by cold shock because these species appeared to congregate in the discharge canal.

1.0 INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND

The United States Nuclear Regulatory Commission (NRC) issued nonradiological Environmental Technical Specifications (ETS) for the Cooper Nuclear Station (CNS) in January 1973. The Cooper Nuclear Station is owned and operated by Nebraska Public Power District (NPPD). The ETS, with amendments, is contained in Appendix B to Operating License Number DPR-46 for the Cooper Nuclear Station. Appendix B sets forth limitations on plant operations applicable to the condenser cooling water discharge temperature, chemical discharges, and intake characteristics. In addition to the ETS requirements, station discharges are also regulated under the state administered NPDES program.

The Cooper Nuclear Station ETS can be divided into three major categories:

1. Operating Limits--These deal with condenser cooling water discharge temperature and chemical releases.
2. Monitoring and Surveillance Program--This requires monitoring the ambient river water temperature and chemical properties above and below the station. This program also evaluates the loss of aquatic life due to station operation.
3. Study and Evaluation Program--This program monitors the river aquatic community (plankton, macroinvertebrates, and fish). It also evaluates the effects of the operations on the aquatic ecosystem.

The objectives of the ETS are to:

1. Protect the aquatic community of the Missouri River in the vicinity of the station from being exposed to excessively high temperature or to a sudden change in water temperature;
2. Assure that chemical discharges from the station do not have adverse impacts on the Missouri River aquatic community; and
3. Evaluate the loss in aquatic life attributed to plant cooling water intake.

ETS defines the duration for each of these three major programs. Both the monitoring and surveillance program and the operating limits are to remain in effect throughout the operating life of the station. Meanwhile, the study and evaluation program shall be conducted for a minimum of 5 years of plant operation unless results of these 5 years of study justify a longer duration. This prompted the production of this assessment document, since plant operations began in July 1974.

Document contents generally follow a standard scientific approach and are arranged in a manner capable of adequately addressing questions on probable plant impacts on near-field and far-field aquatic communities of the Missouri River.

The information contained herein includes, but is not limited to:

1. Documents submitted by NPPD to NRC;
2. Data obtained from Nebraska Department of Environmental Control (DEC);
3. Data obtained from Nebraska Game and Parks Commission (GPC);
4. Data acquired from NPPD environmental consultants;
5. Data obtained from published literature;
6. Results of a meeting held at the plant in February 1981, and observations recorded during a station visit; and
7. Other pertinent data sources.

1.2 APPROACH AND RATIONALE

Cooper Nuclear Station began commercial operation on July 1, 1974. Monitoring of the preoperational aquatic communities has been conducted by NPPD since 1969. Data collected during the 1973 to 1978 period are the primary source of information upon which conclusions in this document were reached, both for preoperational (1969 to June 1974) and operational (July 1974 to 1978) monitoring. Because of numerous changes made in both locations and methods during the early preoperational studies, only the data beginning with 1973 will be compared. Independent calculations and other sources of information were also used. Additional information was gained from visiting the site and the surrounding area.

Based on available data and the results of interviews, the discharge of heated effluents into the Missouri River from Cooper Nuclear Station has occurred for a sufficient time to allow operational impact evaluation. Similarly, data collected on entrainment and impingement (plankton, fish, and fish larvae) were adequate to address the question of the type and magnitude of aquatic life lost to plant intake.

The rationale and approach used in this document for demonstrating the type, magnitude, and duration of the station's impacts are based on the following criteria:[1,2]

1. Reduction of successful completion of the life history of indigenous species;
2. Substantial reduction of community heterogeneity or trophic structure;
3. Substancial increases in abundance and/or distribution of nuisance species;
4. Elimination of species of potential economic (commercial) and/or recreational values;
5. Relation of cooling water intake location, depth of intake, water velocity, and screen design and the existing aquatic community;
6. Changes in odor, or taste of the receiving waters; and
7. Presence (or absence) of appreciable harm to the balanced indigenous community in the vicinity of the plant since operation began.

Biological communities of the Missouri River (including the plant site) have been subjected to various disturbances over the years, primarily due to man-induced changes. The Missouri River in the vicinity of Cooper Nuclear Station is wholly channelized. It consists of rock revetment along the shorelines and various channel training structures in the river. The river is dammed in several locations, and the main channel is maintained for navigation from March through November.[3]

In addition to the alteration of physical habitat, various introduced fish species (e.g., carp) have become very abundant in this reach of the Missouri River. It is presumed that prior to plant operation, there had been a balanced aquatic community in the vicinity of Cooper Nuclear Station.

1.3 DOCUMENTATION FORMAT

This document provides specific information required by NRC for environmental appraisal and possible regulatory action, which is dependent on the outcome of the monitoring programs conducted at Cooper Nuclear Station during the plant's operational period.

Section 2.0 provides a concise description of the plant intake and discharge structures. Furthermore, the discharge zone, existing thermal plume, and ΔT are discussed here in relation to operating limits. Power plant use and operating history will be briefly discussed. This section will include a summary on the contents of the 1973 ETS and any additional modification and/or amendment. A copy of the original and the modified ETS and NPDES permit will be presented in the appendices.

Section 3.0 provides assessments and the major conclusions reached in this document. This section includes a short discussion on potential discharge and intake impacts generally associated with power plant operation. Analyses will be provided on operational impact predictions as projected in 1973.[4] An in-depth analysis of operational impacts observed during the operational years will be provided in Section 3.0. A comparison will be made between preoperational projections to impacts and impacts observed during the operational years. Operational impacts evaluated in this section will be carried out on a trophic-level-by-trophic-level basis.

Section 4.0 summarizes concrete conclusions achieved in this document, based on data, analyses, and discussions presented in Section 3.0.

2.0 STATION DESCRIPTION

2.0 STATION DESCRIPTION

2.1 INTRODUCTION

Cooper Nuclear Station is located on the Nebraska side of the Missouri River at River Mile (RM)532.5. The station utilizes a boiling water reactor and steam turbine generator to produce 778 MW (net) of electrical power. The cooling system is a once-through design that withdraws water from, and discharges to, the Missouri River. When the plant is operating at full load, the heat rejection rate is 5.6×10^9 BTU/hour.

A summary of station discharge temperature is presented in Table 2-1. A precise correlation between ΔT and station operating condition cannot be made, but there is a general trend of increased ΔT and an increased plant capacity factor. This trend can be observed by making comparisons by month among years. These data generally indicate that a higher plant capacity was achieved after the first two years of operation.

2.2 PLANT WATER USE AND COOLING SYSTEM

2.2.1 Plant Water Use

Station operating water for condenser cooling and service water systems is withdrawn from the Missouri River. In addition, local wells are used to produce water that is treated to provide finished water for the station. Water is drawn into the station by four 162,750 gallons-per-minute (gpm) capacity circulating pumps (total: 651,000 gpm). The amount of water withdrawn is dependent upon the number of pumps in use. Chlorination of cooling water is not required for control of bio-fouling at Cooper Nuclear Station because the silt load of the Missouri River provides sufficient abrasion to prevent slime buildup. Chemicals are used in water treatment, liquid waste, sanitary waste, and decontamination systems. Chemical discharges from these systems have generally been at or below the limits specified in the plant NPDES permit and the ETS.

Table 2-1. Summarized Outlet and Calculated Ambient Temperature and Maximum ΔT for Cooper Nuclear Station, 1974 through 1979

	1974*			1975			1976		
	Maximum Discharge T (°F)	Calculated Ambient T (°F)†	Maximum ΔT (°F)	Maximum Discharge T (°F)	Calculated Ambient T (°F)	Maximum ΔT (°F)	Maximum Discharge T (°F)	Calculated Ambient T (°F)	Maximum Δ(°F)
January				74	33	41	74	33	41
February				67.5	[illegible]	34.5	73	33	40
March				71.5	39	32.5	78	47	31
April				78	54.5	23.5	86	55.5	30.5
May	79.2	69.2	10	86	68	18	83	63.5	19.5
June	91	74.2	16.8	94.5	78.5	16	95	73	22
July	86.5	79.3	7.2	96.5	80	16.5	97.5	80.5	17
August	94.1	77.4	16.7	95	80.5	14.5	94.5	77	17.5
September	74.9	63.95	10.95	96.6	77.8	14.8	90.5	76	14.5
October	71.95	55.15	16.8	SHUT DOWN			SHUT DOWN		
November	52.9	47.8	5.1	68	35	33	69	32	37
December				78	36	42	81	32	49

	1977			1978			1979		
	Maximum Discharge T (°F)	Calculated Ambient T (°F)	Maximum ΔT (°F)	Maximum Discharge T (°F)	Calculated Ambient T (°F)	Maximum ΔT (°F)	Maximum Discharge T (°F)	Calculated Ambient T (°F)	Maximum ΔT (°F)
January	82	33	49	69.5	31.5	38	76	33	43
February	84.5	35	49.5	61	32	29	72.5	33	39.5
March	84	35	49	67.5	37.5	30	80.5	45	35.5
April	80.5	50	30.5	66	43	23	80	50	30
May	88.5	68	20.5	89	70.5	18.5	89	69.5	19.5
June	97.5	78.5	19.0	96.5	78.5	18.0	97.5	78.5	19
July	103.0	82	21.0	101	81.5	19.5	100.5	81.5	19
August	96.5	76.5	20.0	101.5	84	17.5	98	80	18
September	93.5	74	19.5	97	76.5	20.5	95.5	79.5	16
October	74	56.5	17.5	89	68	21.0	82	63	19
November	76	44	32.0	71.5	44.5	27.0	70	45.5	24.5
December	70	32	38	69	32.5	36.5	74.5	31.5	43

* Points for 1974 represent 1 day during month.
† Calculated Ambient = Maximum T − Max ΔT, for all dates.

Source: ESE, 1981.

2.2.2 Cooling Water System

Cooper Nuclear Station utilizes a once-through cooling system to dissipate excess heat from the condensers and auxiliary cooling systems. After passage through the condenser, cooling water is discharged back into the river via a 1,000-foot long canal that enters the river at a 60° angle. Warmed water from the circulating system is used for backwashing into the screen well during cold weather to prevent ice from clogging the intake screens and pump intake chambers.

2.3 INTAKE AND DISCHARGE SYSTEMS

2.3.1 Intake Structure

The intake structure (pumphouse) was originally located flush with the protective channel works of the Army Corps of Engineers. In 1974, a guidewall was installed in front of the intake to reduce the amount of sediment being taken into the plant (see Figure 2-1). The structure is located on the west side of the Missouri River at River Mile 532.5.

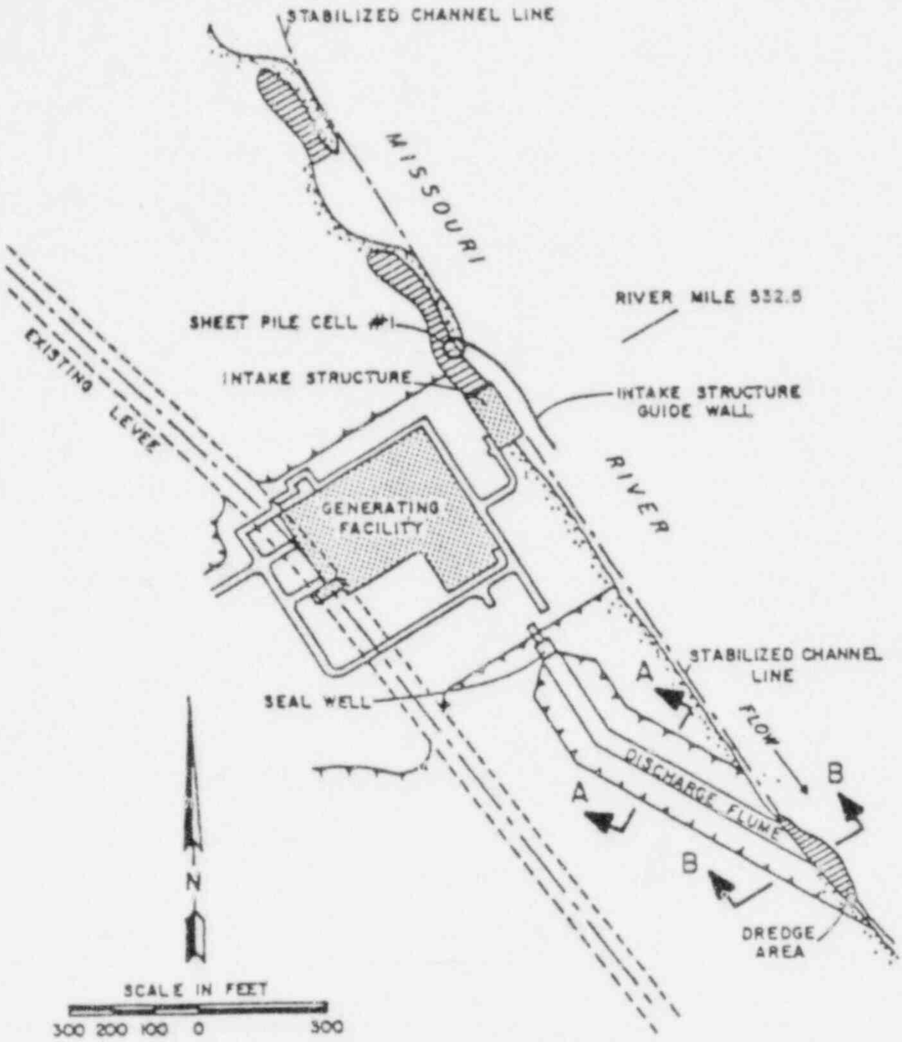
Cooling water is drawn into the plant through eight screen bays. Large items and debris are prevented from entering the intake bays by fixed trash racks. The cooling water passes through traveling screens (3/8-inch mesh) and then through the cooling systems (see Figure 2-2). The traveling screens are backwashed with water. The materials washed from the screens (to include fish) are collected in a common trough and discharged into the river via a pipe.

2.3.2 Discharge Structure

Heated water leaving Cooper Nuclear Station is discharged into the Missouri River via a 1,000-foot long discharge canal (see Figures 2-1 and 2-3). The discharge canal is situated approximately 60° in the direction of river flow and is about 120 feet wide and 5 feet deep at the outlet.

2.4 STATION ENVIRONMENTAL TECHNICAL SPECIFICATIONS

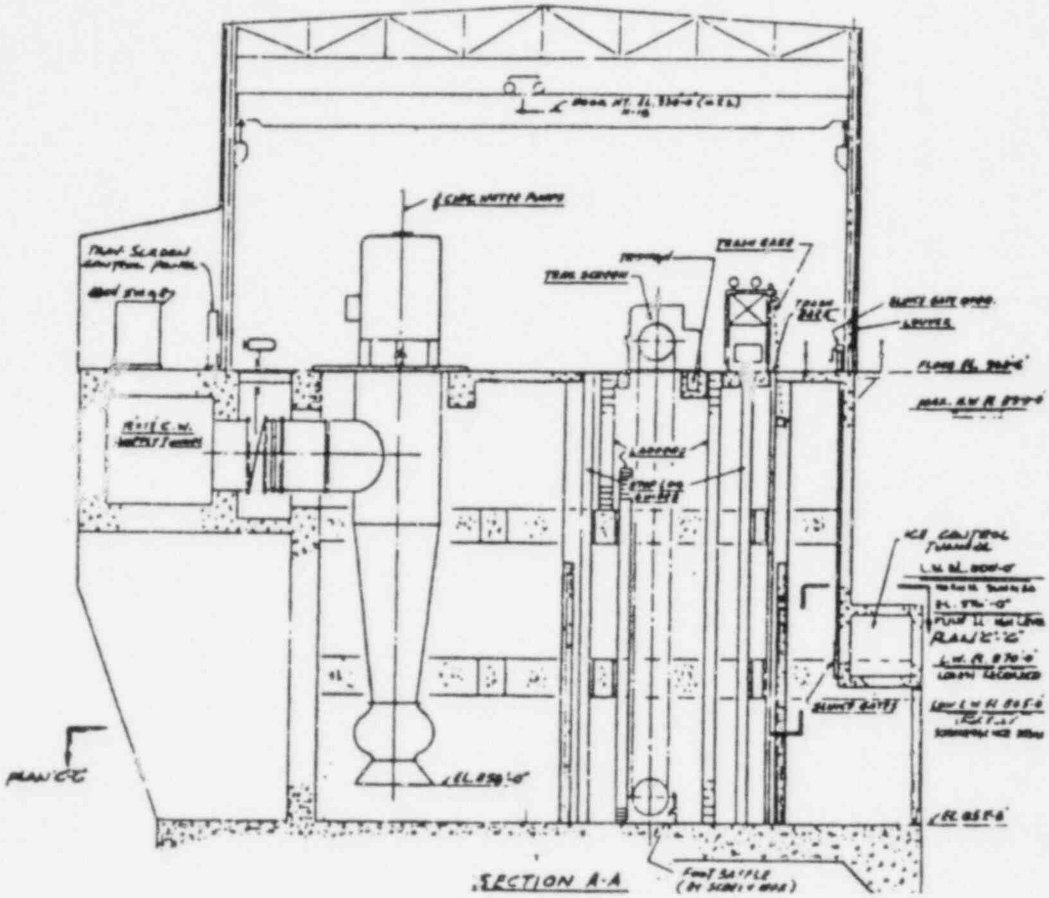
Cooper Nuclear Station is operated under NRC operating License Number DPR-46 and the Environmental Technical Specifications, Appendix B



SOURCE: 316 A AND B DEMONSTRATION, NPPD, 1975.

Figure 2-1
SITE CHARACTERISTICS AT COOPER NUCLEAR STATION, BROWNVILLE, NEBRASKA

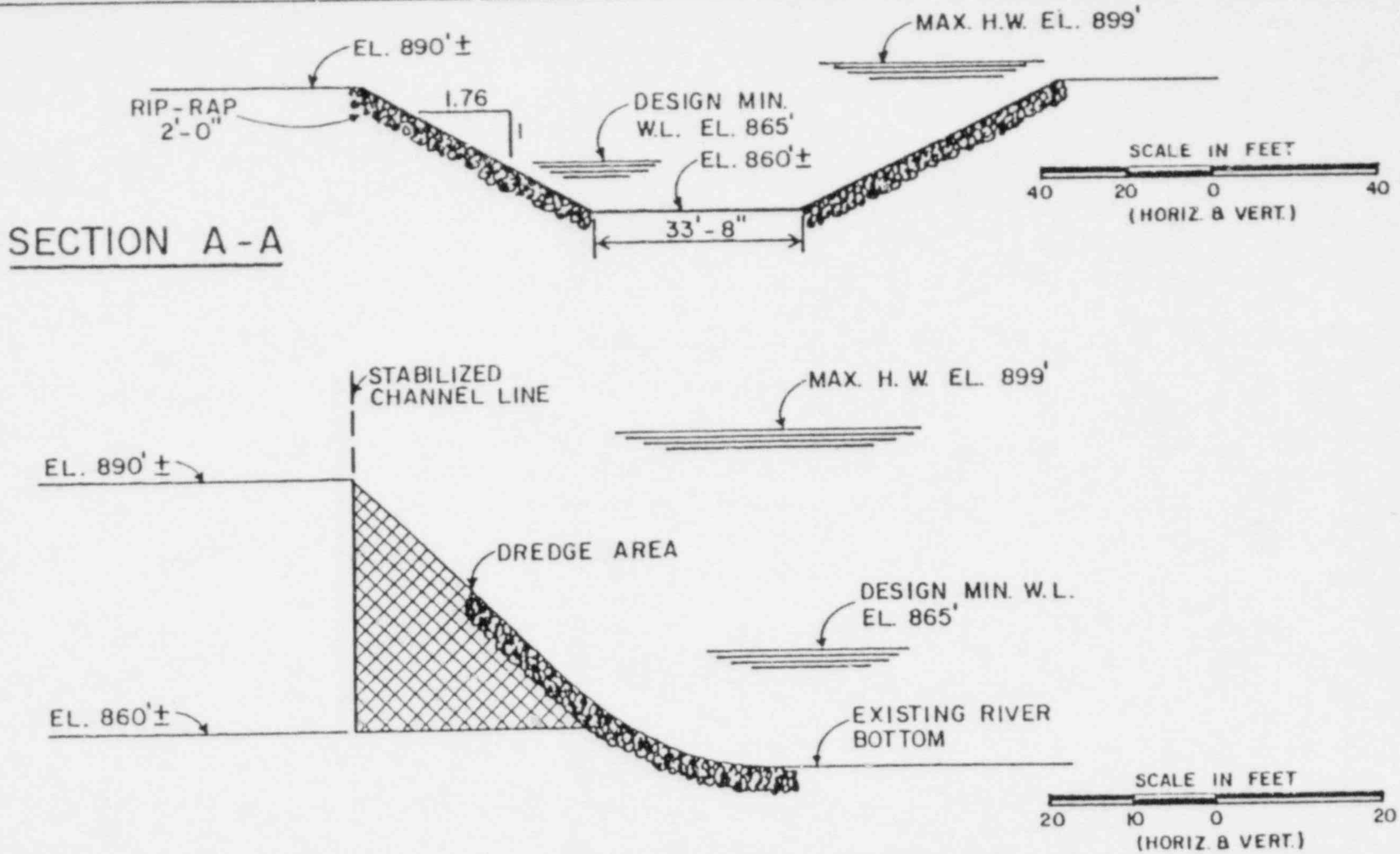
COOPER NUCLEAR STATION



SOURCE: NPPD.

Figure 2-2
ENGINEERING DRAWING OF THE INTAKE STRUCTURE AT COOPER NUCLEAR STATION

COOPER NUCLEAR STATION



SOURCE: 316 A AND B DEMONSTRATION, NPPD 1975.

Figure 2-3
CROSS SECTIONS OF THE DISCHARGE CANAL AT COOPER NUCLEAR STATION, BROWNVILLE, NEBRASKA

COOPER NUCLEAR STATION

(see Appendix A). The original ETSs were issued in January 1973 and have been amended several times. Because preoperational and operational data (on which the analyses presented here are based) cover the period from 1973 to 1978, the 1973 ETSs are utilized for program compliance. A copy of the 1973 ETS is presented in Appendix A. In addition to the ETS, Cooper Station also operates in compliance with limits set in the Nebraska NPDES Permit Number NE 0001244. The 1973 ETSs include the following major classes:

1. Operating Limits;
2. Monitoring and Surveillance Program; and
3. Study and Evaluation Program.

The following is a summary of the contents of programs covered in the ETS and limits placed on station operations.

2.4.1 Operating Limits (Details are in Appendices A and B)

1. Condenser Cooling Water Temperature Limits
   a. Maximum discharge temperature shall not exceed 103°F.
   b. Maximum ΔT shall not exceed 18°F, except during changes in power level or when backwashing.
   c. Maximum ΔT from November to April shall not exceed 30°F when tempering occurs.
   d. Maximum ΔT shall not exceed 32°F during backwashing and 22°F at other times when a circulating water pump is down for maintenance.
   e. Normal plant operation shall be controlled so that changes in the river temperature shall not exceed 2°F per hour at the boundary of the mixing zone (7,500 feet downstream of the discharge).

2. Chemical Discharges
   a. Total residual chlorine: not to exceed 0.1 milligrams per liter (mg/1).
   b. Turbidity from waste water shall not impact more than a 10 percent increase to the water in the discharge canal.

c. Suspended or settable solids (SS): not to cause more than a 10 percent increase in turbidity to water in the discharge canal.

d. Toxic substances: none which will render water unusable with standard municipal treatment.

e. Dissolved solids: shall not increase the conductivity by more than 10 percent in the discharge canal.

f. pH: between 6.5 and 9.0 pH units.

2.4.2 Monitoring and Surveillance Program

1. Monitoring of Thermal and Chemical Discharges

a. Continuous monitoring of ambient and discharge temperatures.

b. Thermal plume monitoring shall be conducted monthly (when river conditions permit) for one year. The 3-dimensional extent and isotherm structure of the plume will be measured.

c. Duplicate water quality samples for laboratory analyses will be collected monthly (May through November) from four locations. Sampling will be restricted to the intake and discharge during the remainder of the year.

d. Physical measurements and field analyses will include: DO, pH, total alkalinity and turbidity, field chemistry, and nutrient analyses will also be performed (Appendix A, Tables A-4 through A-6).

2. Monitoring and Reporting on Loss of Biota by Impingement

a. Fish impingment shall be monitored one hour per day for a minimum of five days per week to include nocturnal periods.

b. Data for each sampling period will include time of collection, size, weight, and physical condition by species for each fish impinged.

3. Monitoring of Passage Effects on Planktonic Organisms

   a. Monthly sampling will be conducted in all months of the year to determine the thermal and mechanical effects of condenser passage on dominant members of phytoplankton and zooplankton.

   b. Monthly samples will be collected for determining zooplankton survival and phytoplankton viability.

2.4.3 Study and Evaluation Programs

Phytoplankton--Duplicate samples for phytoplankton analysis will be collected monthly (May through November) at five locations. Samples will be collected with a Kemmerer sampler. Analyses will provide enumeration and species composition data. This sampling program was terminated in mid-1978.

Zooplankton--Duplicate samples for zooplankton analysis will be collected using the same locations and timetables as phytoplankton sampling. Samples will be collected with a Miller plankton sampler equipped with a #10 (153-u mesh) plankton net. Analyses will determine abundance and seasonal occurrence. Sampling for zooplankton was terminated in mid-1978.

Periphyton--Periphyton samples will be collected from artificial substrates anchored at five locations in the river, from June through November. Analyses will determine species composition, relative abundance and biomass (ash-free weight).

Macroinvertebrates--Samples for macroinvertebrates will consist of collections from both natural and artificial substrates at five locations. Samples will be analyzed to determine species composition, abundance, and diversity.

Fish--Fish will be sampled monthly (May through November) at three locations from both the Nebraska and Missouri shorelines. Sampling will consist of collections made by electroshocking and seine hauls. In

addition, fish larvae will be collected twice a month from May through July at five locations.

The operating limits and monitoring programs must be conducted throughout the expected life of the station. However, the biological study and evaluation programs were deleted in 1979 after 5 years of operational data had been gathered.

2.5 NPDES PERMIT LIMITATIONS

The Department of Environmental Control (DEC) administers NPDES permitting in Nebraska, rather than the regional EPA Administrator. This permit stipulates discharge limits and monitoring requirements for all effluents discharged into the Missouri River from Cooper Nuclear Station. A review of the ETS and NPDES monitoring requirements for the discharge indicated a great deal of redundancy in these requirements. These duplications exist in the frequency of measurements, location, and most chemical parameters. Specifications of the permit set limits on, and/or require measurements of the following: daily flow, maximum temperature, and a variety of chemical parameters. Results of monitoring are summarized monthly and reported to the Nebraska DEC quarterly. A copy of the Cooper Nuclear Station NPDES permit is included in Appendix B of this report.

2.6 SUMMARY OF STATION DESCRIPTION

Cooper Nuclear Station utilizes a boiling water reactor to drive a steam turbine generator to produce 778 MW (net) of electrical power. A once-through cooling system utilizes the Missouri River as both a water source and receiving water body. The station intake and discharge structures are both shoreline features. At maximum capacity the station withdraws a total of 651,000 gallons of water per minute. The station operates under NRC operating licensing and Nebraska NPDES permit.

3.0 ENVIRONMENTAL IMPACT ASSESSEMENT

3.0 ENVIRONMENTAL IMPACT ASSESSMENT

3.1 POTENTIAL IMPACTS OF INTAKE AND DISCHARGE

This section presents a discussion on potential direct and indirect impacts that are generally associated with power plant operations. This summary discussion is general; however, site-specific data are used when available. It is designed to clarify those sensitive areas likely to change by intake and discharge modes. It also establishes a basis of comparison for the impact analyses of Cooper Nuclear Station.

3.1.1 Potential Direct Effects

3.1.1.1 Thermal Tolerance and Threshold--Direct effects of heat on aquatic organisms are dependent on a matrix of factors, the most significant of which are rate of change of ambient water temperature, ΔT, and the duration of exposure of an organism to temperature. Organismal responses to a heated effluent are species specific. Organisms exposed to a heated discharge can experience acute or latent effects. The first results in an immediate response, such as an increased respiration rate, while the latter can include a host of other changes to include changes in growth, reproduction patterns, and other physiological factors. Each organism has a zone of tolerance and a thermal preference. Thermal preference changes with season and results in avoidance or attraction to a heated zone. Summer preference generally results in plume avoidance when preferred temperature is below that of the plume. In cold months, preference is for warmer effluents which tend to attract organisms to plant plumes.

During the period of warmer water temperature (June to September), the Missouri River's ambient water temperature ranges from 61 to 83°F. Maximum plant discharge temperatures from Cooper Nuclear Station during the monitoring period from 1974 to 1978 was 103°F in July 1977.[3] Maximum temperature rise, ΔT, measured at the station from 1974 to 1978 was 49.5°F in February 1977.[3] A maximum discharge temperature of 103°F is reduced by dilution with the receiving waters. However limited the mixing zone, this high temperature value exceeds the summer lethal thresholds for several fish species collected from the Missouri River. Figures 3-1 through 3-4 show the range of the 2° and 5°F surface isotherms by season for Cooper Nuclear Station.

Thermal tolerance limits differ for different life stages of the same species. It is a well established fact that fish tend to avoid higher temperatures during the summer period, but are attracted to higher water temperature during cold periods.[5,6]

3.1.1.2 Plant Shutdown--The potential for cold shock impact due to Cooper Nuclear Station was not evaluated by NPPD, however, the potential for cold shock exists. Cold shock may occur when the addition of heated water is interrupted during the winter months due to plant shutdown. The severity of cold shock stems from lack of physiological ability of aquatic organisms to adjust rapidly to declining water temperature. Generally, fish have greater sensitivity to decreasing water temperature as compared to corresponding increases in water temperature. During the monitoring program from 1974 to 1978, Cooper Nuclear Station shutdown occurred on different occasions during the cold months (e.g., 16 days in December 1974, 5 days in February 1975, October 1975, and October 1976).

No cold shock-associated fish kills have been reported from Cooper Nuclear Station. It should be noted, however, that the sampling program annually ended with the collection of November samples and did not resume until May. Because there was no mid-winter sampling program and there is virtually no river use by vessels during this time, minor fish kill probably would be unnoticed. Because of lack of site-specific data during these critical time periods, it must be concluded from the literature that some cold shock mortalities have probably occurred as a result of unscheduled plant shutdown during mid-winter periods.

3.1.1.3 Impingement--Impingement impacts result when organisms too large to pass through the intake screens become trapped. Juvenile and adult fish and larger invertebrates are prime candidates for impingement.

Several factors interact to determine the number of organisms, species, and size classes, impinged on power plant screens. These factors are site specific and may change from year to year, seasonally, monthly, and daily. Therefore, it is imperative in impact studies to emphasize trends and relationships of impingement to the ecosystem. The numerical derivations of impingement become probabilistic rather than deterministic.

3.1.1.4 Entrainment--Drifting macroinvertebrates, free-floating microscopic plants and animals, and fish eggs and larvae are subject to thermal shock and mechanical stresses by passage through the plant cooling water system. Passage of aquatic organisms through the plant condenser could result in no effect or in an instantaneous mortality or to changes in the physiological conditions of the organisms which ultimately affect their survivorship. Several factors act both separately, and in combination, to determine the fate of organisms passing through the condenser. These factors include ΔT across the condenser, time of exposure, mechanical abrasions, and pressure changes.

3.1.2 Potential Indirect Effects

Cooper Nuclear Station has a shoreline discharge. That station's discharge could result in the following:

1. Water movements could draw eggs, larvae, and other free-floating organisms into the heated plume (plume entrainment), thus exposing them to temperatures higher than ambient.
2. Production of currents act as a near field attractant.
3. Movement of plume-entrapped organisms to the surface exposes these organisms to increased predation.
4. Potential reduction in dissolved oxygen by heating or increased biological oxygen demands may occur.

3.1.3 Aesthetic Charges in Missouri River

Aesthetic problems associated with power plants vary from appearance of intake and discharge structures to fish die-offs and changes in quality of receiving waters.

The Missouri River, in the vicinity of the plant, has been wholly channelized; thus, a variety of habitats has been eliminated, and the surface area of the river has been greatly reduced. This in itself plays a role in the appearance of the river.

3.2 PREOPERATIONAL FINAL ENVIRONMENTAL STATEMENT PROJECTIONS OF IMPACTS

The Final Environmental Statement (FES)[4] for Cooper Nuclear Station, discussed potential environmental impacts of station operation on the Missouri River aquatic biota. These impact projections were based on preoperational monitoring from 1969 to 1973.[8] The FES concluded in its impact projection, (see pages i through iii), that intake velocities of approximately 1.3 fps across the intake screen may result in some loss of fish by entrainment or impingement. Biota entrained in the cooling water will experience a substantial mortality rate. However, losses due to entrainment are expected to be small since only 4 percent of the river drift will normally be entrained during usual summer flows. Worst-case prediction estimated a loss of 20 percent of the drift biota during unusually low flows.

The following four factors associated with plant operations have potentially detrimental effects on Missouri River aquatic life in the vicinity of the station:

1. Effects resulting from organismic exposure to elevated water temperature at the point of discharge and in the mixing zone;
2. Effects on river biota by chemical waste discharges from the waste treatment plant (lagoons);
3. Impingement of fish on cooling water intake traveling screens; and
4. Entrainment of plankton, ichthyoplankton, and drift benthic organisms in the condenser cooling water.

The following sections present arguments and projections of impacts presented in Cooper Nuclear Station FES on each of the four previously discussed parameters.

3.2.1 Thermal Discharges

1. Freshwater fishes, including those of the Missouri River near Cooper Nuclear Station, are sensitive to temperature and generally will avoid the discharge zone when water temperatures exceed organismic-preferred water temperature. Conversely, fish will be attracted to this warm water zone during the winter months.
2. During warm summer months, water temperatures of the nearshore area (for approximately 0.5 mile) below the discharge will equal or exceed 93°F. The 90°F isotherm was predicted to extend downstream for nearly a mile. Because of river configuration downstream of Cooper Nuclear Station, the plume will be restricted to the Nebraska shoreline. The zone was predicted to extend no more than 200 feet from the shore during summer and thus would not be a barrier to fish movement.
3. The effects of thermal loading on the aquatic community in general were predicted to impact small areas during the summer period.
4. Fish are attracted to thermal discharges during cold seasons. Rapid reduction in cooling water discharge temperature during these periods will result in mortality or thermal stresses to fish and other aquatic biota found in the mixing zones. At Cooper Nuclear Station, fish may find warm water discharges attractive from December to February when the Missouri River water temperatures are lowest.

3.2.2 Entrainment and Impingement

1. It was assumed for predictive purposes that the number of drifting organisms entrained by Cooper Nuclear Station was in direct proportion to the fraction of the river flow used by the plant.
2. Entrained organisms would be subjected to an abrupt increase in temperature (approximately 18°F). The worst-case situation would occur during the summer when entrained organisms would be

subjected to elevated temperatures for as long as 20 minutes before leaving the discharge canal.

3. It was anticipated that most, if not all, of the organisms subjected to entrainment during the summer would be killed either by temperature or mechanical effects.
4. Several factors govern impingement rates of juvenile and adult fish, among which is intake screen approach velocity. Approach velocity at Cooper Nuclear Station was estimated to range from less than 2 fps to 2.5 fps at low river flow. An approach velocity of 0.75 fps would minimize impingement for some species such as white crappie and channel catfish (based on fish swim speed). However, it was concluded that any small fish less than 3 inches long that drifted by the plant would be impinged on the screens and die.
5. It was concluded that, since the intake structure is located in the region of high current velocities, which is not an area of regular habitat for small fish, insignificant numbers of fish would be lost.

3.2.3 Chemical Effluents

Chemical effluents from station water treatment and sanitary treatment plants were not anticipated to pose any threat to existing aquatic biota in the river. These liquid effluents would contain such pollutants as chlorides, ammonium hydroxides, orthophosphates, silica, and others in concentrations below those considered toxic to aquatic biota.

3.3 OPERATIONAL IMPACTS

Summary and conclusions of operational impacts presented here represent the findings of 5 years (1974 through 1978)[9,10,11,12,13] of monitoring effects of Cooper Nuclear Station on the aquatic communities of the Missouri River. Conclusions presented in this section were based on data interpretation by Nebraska Public Power District's (NPPD) consultants. These conclusions are to be distinguished from those of Section 3.4. The latter is based on independent evaluation by ESE reviewers.

3.3.1 Thermal Impacts

1. River flow conditions and total plant production British Thermal Units (BTUs) dictate, to a large extent, thermal plume dimensions. Under most conditions of plant operations and river flow, the mixing zone extended to a distance of less than 2,000 feet downriver from plant outfall, for the 5°F isotherm, and 3,290 feet downstream for the winter 10°F isotherm.
2. The thermal plume from Cooper Nuclear Station was shore-attached along the Nebraska shore. Excess temperature decreases rapidly in the first 1,000 feet downstream of the discharge.
3. Impacts on river fish populations were not detected. Missouri River fish density in the vicinity of the station changed between years; however, species composition was relatively stable.
4. Production of macroinvertebrates below the outfall was not limited by the addition of heat.

3.3.2 Entrainment and Impingement

1. The total intake screen impacts on the river fish community amounted to the calculated removal of 484,859 fish (July 1974 to December 1978) by impingement.[9,10,11,12,13]
2. The majority of impinged fish were young-of-the-year or yearling.
3. Generally, the potential number of harvestable fish lost to impingement was low in 1975, 1976, 1977, and 1978. In 1974, large numbers were impinged (see Table 3-1). It was suggested[9] that construction of the intake guide wall was responsible for this high impingement rate.
4. Larvae of game and commercial fish species constituted a minor portion of the total entrained fish larvae. Consequently, potential impacts on game and commercial species were insignificant.

Table 3-1. Estimated Annual Fish Impingement at Cooper Nuclear Station, 1974 to 1978

	Total	Sample Size
1974	252,300	153 hours
1975	45,990	129 hours
1976	63,245	162 hours
1977	40,296	233 hours
1978	83,028	27 hours
TOTAL	484,859	704 hours

Source: ESE, Compiled from Reference Document Numbers 9, 10, 11, 12, and 13.

5. Cooper Nuclear Station entrained 2.3 to 12.9 percent of all river larvae passing the plant. It was indicated that not all larvae entrained were killed, and various survival rates were estimated for larvae passed through the condenser.[9,10,11,12,13]
6. Experience has shown that plant entrainment mortality is attributed to a combination of thermal and mechanical effects.

3.3.3 Agency Study

In 1970, a meeting of concerned state and federal agencies resulted in a plan to investigate selected environmental effects associated with warm water discharges from Fort Calhoun and Cooper Nucl‹ . Stations. The study was divided into three major areas (periph· ‹ and macroinvertebrates, fish, and chemical-physical). Results ‹ these agency studies e.g., Hesse and Wallace 1976[51] or studies funded by this group (Cada 1977),[47] are referenced and compared in the appropriate sections of this document.

3.4 EVALUATION OF OBSERVED IMPACTS

This section provides an evaluation of impacts of Cooper Nuclear Station operations on the aquatic biota of the Missouri River near the station. This evaluation was made based on comparisons of preoperational and operational data sets, when available, as well as changes which occurred during the 1974 to 1978 period. In cases where there are not adequate baseline data to warrant comparison of a parameter, professional judgement (based upon supportive published data) was made.

In this section, three major areas will be addressed. These are thermal effects, entrainment, and impingement. At the end of each section, a conclusion will be given.

3.4.1 Thermal Effects

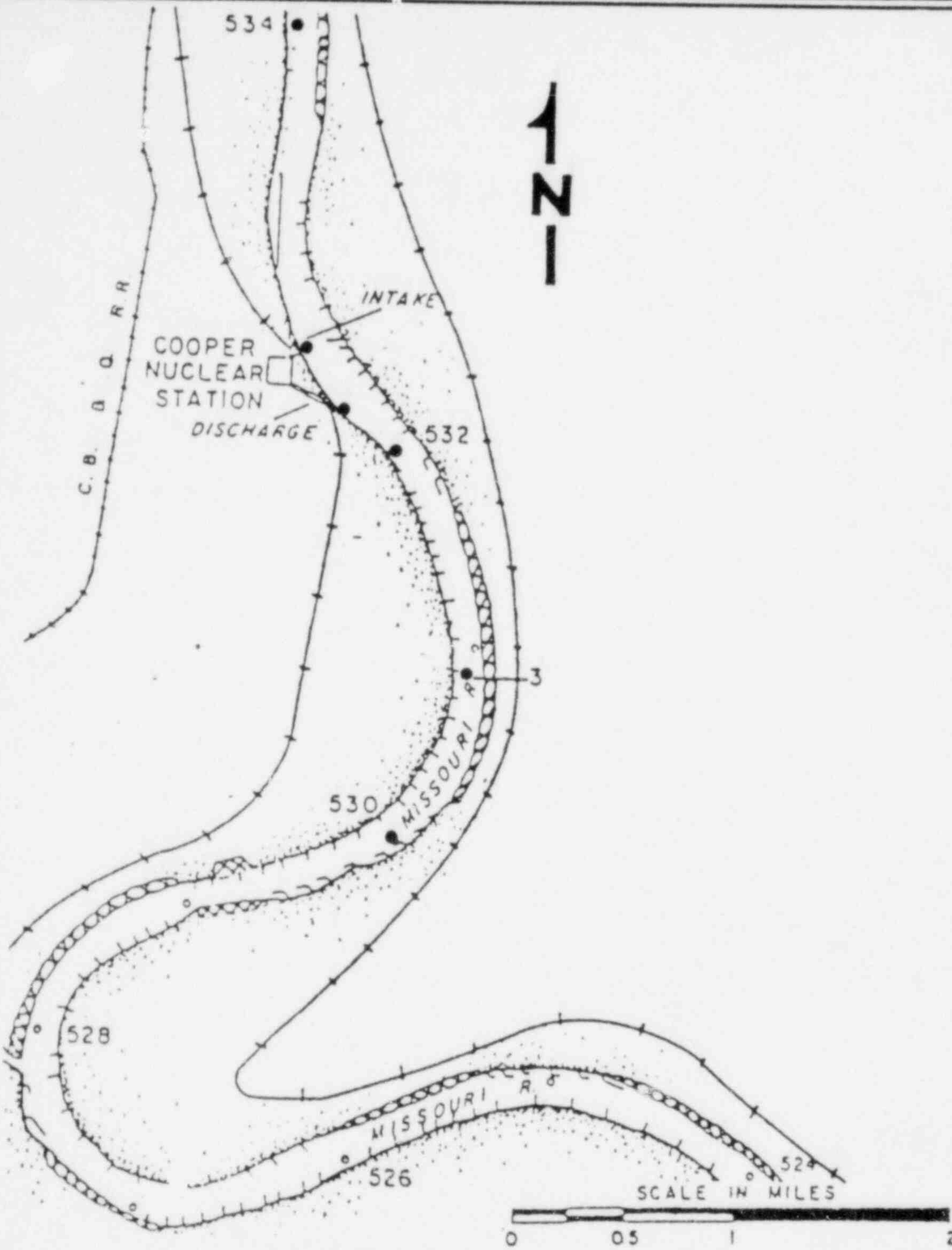
By drawing in a large volume of water for cooling the plant's condenser, planktonic organisms are subjected to acute interactions of thermal and

mechanical stress. Additionally, by raising the temperature of the receiving water near the site of discharge, attached and floating organisms in the zone of influence may be influenced but in a less severe manner than those entrained.

3.4.1.1 Phytoplankton--Duplicate phytoplankton samples were collected monthly from the Missouri River near Cooper Nuclear Station. Samples were collected 1 meter below the surface with a nonmetallic water sampler. Phytoplankton and periphyton collections were begun in 1970 and 1972, respectively. The preoperational phase ended in July 1974 when Cooper Nuclear Station began commercial operation. Sampling locations are shown on Figure 3-1.

In 1973, studies were conducted to determine the effects associated with mechanical entrainment. During this time period, the station's circulating water pumps were operated, but there was no heat exchanged across the condenser. Analysis of this preoperational phytoplankton entrainment data indicated that there were few effects associated with condenser passage without thermal loading. Comparisons between intake and discharge samples indicated similiar trends in densities and composition at 3 and 72 hours after condenser passage (see Table 3-2). Carbon fixation rates were usually higher from the discharge canal (see Table 3-3). Chlorophyll a concentrations measured after 72 hours were lower from the discharge for two out of the three sampling periods (see Table 3-3). Statistical comparisons of these parameters, however, indicated that most of the differences noted were not statistically significant.[8]

Comparisons of the operational phytoplankton data were made beginning with July 1974 through December 1977. A modification to the ETS resulted in only two sample collections in 1978.[13] Because of this, comparisons were confined to the 1974 through 1977 periods. Total phytoplankton abundances were summarized for the period 1974 through 1977.[12] Figure 3-2 illustrates these summarized data.



SOURCE: ESE MODIFICATION FROM REFERENCE DOCUMENT NUMBER 13.

Figure 3-1
PHYTOPLANKTON AND PERIPHYTON SAMPLING LOCATIONS

COOPER NUCLEAR STATION

Table 3-2. Summary of Major Groups of Phytoplankton Collected in the Missouri River near Cooper Nuclear Station and Analyzed 3 and 72 Hours After Collection, September to November 1973

Sampling Date and Location		Total Phytoplankton Units/ml	Bacillariophyta (Diatoms)		Chlorophyta (Greens)		Cyanophyta (Blue-Greens)	
			Units/ml	Percent	Units/ml	Percent	Units/ml	Percent
14-17 September								
Intake	3 hours	17,420*	13,523	77.6	3,094	17.8	750	4.3
	72 hours	56,134	41,850	74.6	13,905	24.8	324	0.6
Discharge	3 hours	18,597	15,766	84.8	2,506	13.5	313	1.7
	72 hours	68,003	55,785	82.0	12,167	17.9	29	<0.1
17-20 October								
Intake	3 hours	10,483	10,019	95.6	421	4.0	38	0.4
	72 hours	15,272	12,722	83.2	2,446	16.0	85	0.6
Discharge	3 hours	10,466	9,932	94.9	488	4.7	27	0.3
	72 hours	15,097	12,309	81.5	2,606	17.3	153	1.0
27-30 November								
Intake	3 hours	14,878	14,766	99.3	82	0.6	15	0.1
	72 hours	12,376	12,232	98.8	135	1.1	0	0.0
Discharge	3 hours	13,722	13,619	99.3	85	0.6	8	0.1
	72 hours	13,883	13,685	98.6	185	1.3	0	0.0

* Mean of two replicates.

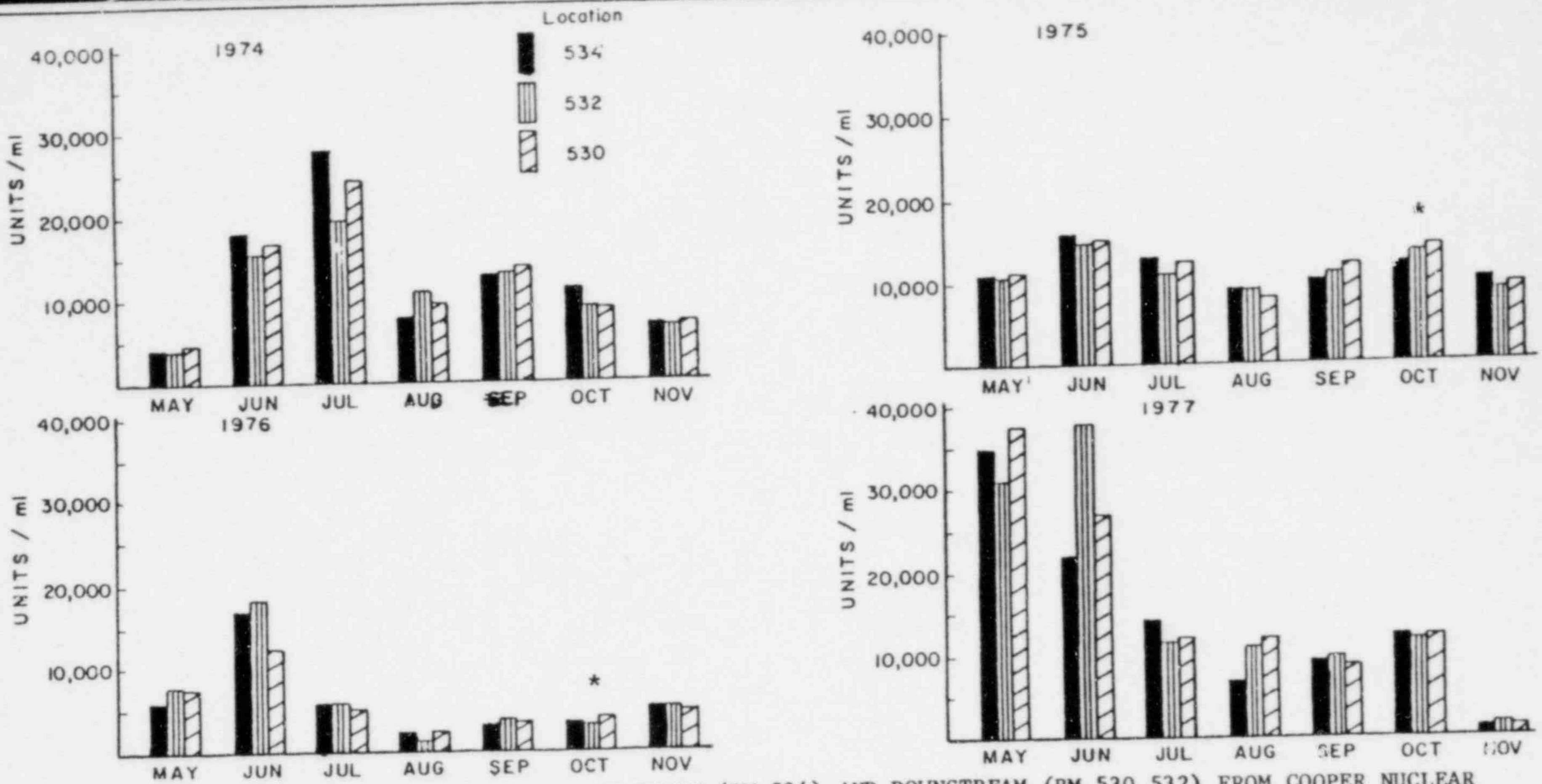
Source: Reference Document Number 8.

Table 3-3. Comparison of Mean Carbon Fixation Rates and Chlorophyll a Concentrations Between Locations, Cooper Nuclear Station, September to November 1973

	Hours	Intake	Discharge	Significant ($p < 0.05$)
Carbon Fixation Rates* (mg C/m^3 per hour)				
14-17 September	3	179.62	187.61	No
	24	239.69	318.78	No
	48	308.82	451.03	Yes
	72	367.05	422.48	No
17-20 October	3	98.59	98.53	No
	24	127.36	134.16	No
	48	199.83	209.24	No
	72	297.17	309.01	No
27-30 November	3	32.64	31.82	No
	24	20.63	27.01	No
	48	23.77	27.78	No
	72	31.05	38.58	No
Chlorophyll a* (mg Chl a/m^3)				
14-17 September	3	35.50	30.00	No
	24	50.50	51.50	No
	48	63.25	57.25	No
	72	63.00	53.00	No
17-20 October	3	20.33	21.25	No
	24	25.50	22.50	No
	48	35.75	33.00	No
	72	53.25	35.00	No
27-30 November	3	14.28	14.93	No
	24	12.88	12.20	No
	48	11.53	13.18	No
	72	13.68	14.48	No

*Mean of two replicates, four subsamples per replicate.

Source: Reference Document Number 8.



SAMPLING LOCATIONS IN THE MISSOURI RIVER UPSTREAM (RM 534) AND DOWNSTREAM (RM 530, 532) FROM COOPER NUCLEAR STATION, MAY TO NOVEMBER, 1974-1977.

* Plant was not operating during these periods.

SOURCE: ESE MODIFICATION FROM REFERENCE DOCUMENT NUMBER 12.

Figure 3-2
PHYTOPLANKTON ABUNDANCE AT SAMPLING LOCATIONS

COOPER NUCLEAR STATION

While interpreting this figure, several factors should be noted. Data beginning with July 1974 are considered operational with the exceptions of October 1975 and 1976 when Cooper Nuclear Station was shutdown. Location 534 served as the upstream reference, and Locations 532, 530 represented the areas presumably influenced by plant discharge. Trend analysis to determine station-related effects were made complicated by virtue of, natural variability, sampling artifacts and varying plant operating levels. For example, during 1975 Cooper Nuclear Station operation varied from 0-100 percent of turbine capacity.[14] The most notable effects of station operation on phytoplankton abundance would be predicted to occur during the July to August periods because of high absolute temperatures. Examination of the data (see Figure 3-2), however, does not fully substantiate this contention.

In 3 out of the 4 years during July, phytoplankton abundances were lower at Location 532 (below the discharge) compared to reference Location 534. Also, abundances at Location 530 increased to approximately the same level as the reference, indicating possible recovery. August data, with the exception of 1976 (see Figure 3-2), however, did not support the trend observed for July sampling periods. It should also be noted that no increase or decrease in abundances were indicated by the data for the early winter but the general sampling program annually ended in November, thus precluding mid- and late winter analysis. During other sampling periods, no consistent trends of increased or diminished densities were apparent.

A summary of Shannon's species diversity indicies (see Table 3-4) for 1973 (preoperational) through 1977 indicated that no effects on diversity were detected by the sampling program. There were no shifts or major changes in the phytoplankton community composition reported for Cooper Nuclear Station during the operational monitoring program.[9,10,11,12,13]

Primary productivity measures, determined by carbon fixation rates and chlorophyll a concentration did indicate effects related to station operation. Sampling for these parameters was conducted monthly

Table 3-4. Shannon's Species Diversity Indices* for Phytoplankton Collected from the Missouri River Near Cooper Nuclear Station, May to November 1973 to 1978†

Year	Location	May	June	July	August	September	October	November
1973	RM534	2.30	2.89	2.61	2.42	2.93	2.99	2.91
	RM532	2.38	2.81	2.44	2.35	3.00	2.91	2.88
	RM530	2.29	2.94	2.68	2.43	2.90	2.91	2.93
1974	RM534	2.21	3.14	1.70	2.21	2.30	2.18	2.31
	RM532	2.14	3.01	1.65	2.14	2.11	2.06	2.33
	RM530	2.45	3.17	1.59	2.27	2.04	2.17	2.03
1975	RM534	2.99	3.48	2.63	2.83	2.64	1.99	2.34
	RM532	3.03	3.48	2.74	2.72	2.60	2.18	2.31
	RM530	2.90	3.51	2.79	2.52	2.53	2.18	2.45
1976	RM534	2.67	2.71	2.81	2.85	2.87	3.20	2.53
	RM532	2.34	2.71	2.55	2.97	2.98	3.21	2.44
	RM530	2.22	2.56	2.90	2.91	3.07	3.40	2.54
1977	RM534	2.15	3.02	2.54	3.05	3.07	2.79	2.38
	RM532	2.45	2.89	2.13	3.13	3.05	2.82	2.51
	RM530	2.64	2.52	2.43	3.10	2.92	2.90	2.21

* H values calculated to the base e.

† Phytoplankton sampling was discontinued in June 1978.

RM River Mile

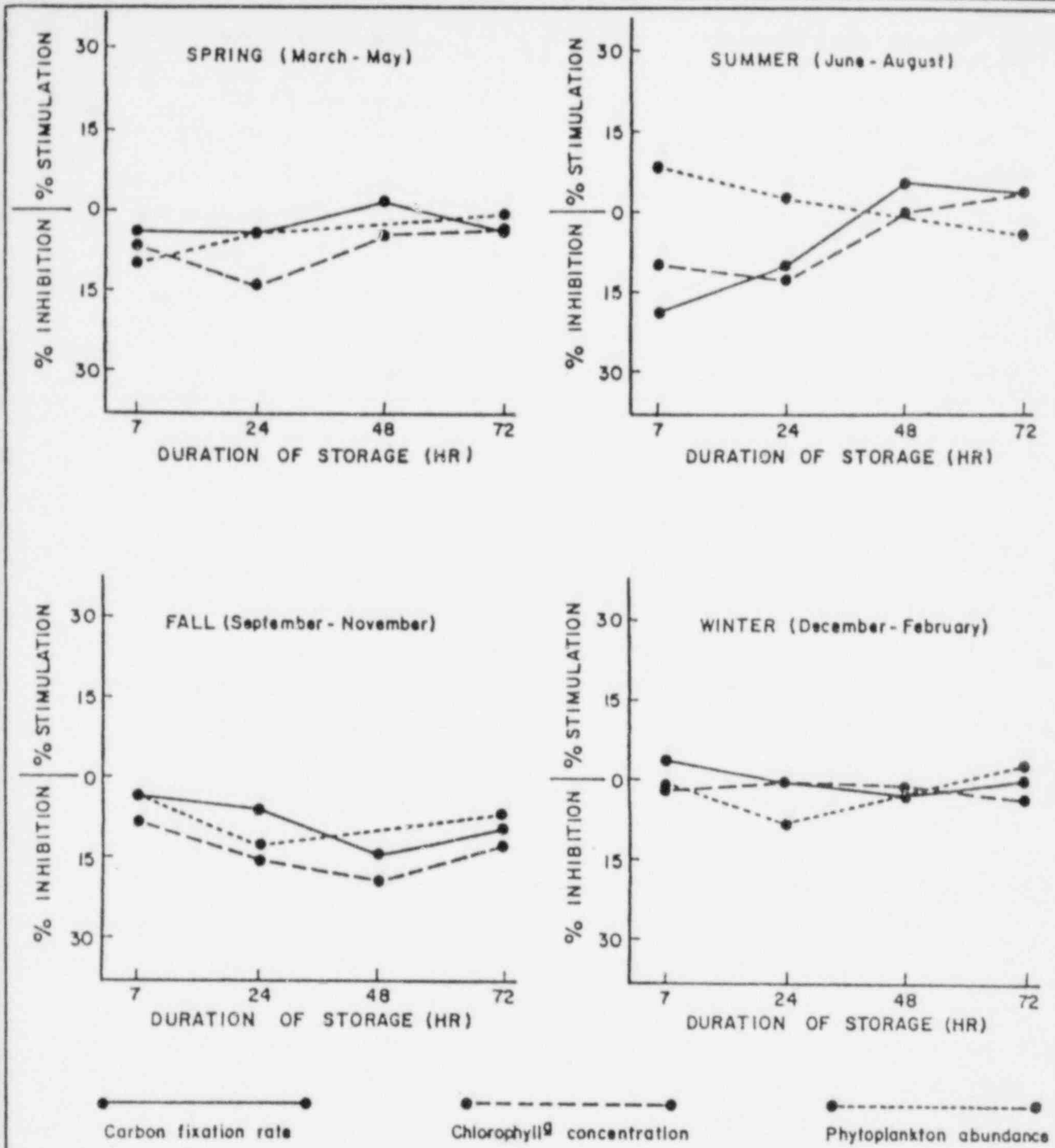
Source: Reference Documents Numbers 12 and 13.

throughout the year and thus provided complete seasonal comparisons. Samples were collected from the intake, discharge, and Location 3 (see Figure 3-1). In general, these studies indicated that effects of condenser passage varied with season. Initial (7 hour) effects usually indicated slight stimulation during the winter and minor inhibition of productivity during the remainder of the year (see Figure 3-3). There was also some evidence of a shift in community composition in samples collected from the discharge canal (see Tables 3-5, 3-6, and 3-7). These changes, at times, favored the more tolerant greens and blue-greens over the diatoms but were not consistent enough, or of sufficient magnitude, to demonstrate major plant-related effects.

Periphyton

Periphytic algae was collected from artificial substrates suspended in the Missouri River. The artificial substrates consisted of plexiglas plates. Collections were made monthly from June through November. Sampling locations are indicated in Figure 3-1. During the first two years of operational monitoring, few differences were noted in the downstream periphytic community.[12] Beginning in 1976, artificial substrates were placed in the discharge canal as well as the river.

Species diversity indicies were compiled for the period 1973 through 1978 (see Table 3-8). Comparisons of these data indicated a few consistent trends of decreased indices values that appeared related to station operation. These lowered values were usually noted for the July to August period, principally in the discharge canal. Comparisons of average annual biomass (see Table 3-9) production indicated that higher production occurred at downstream Location 532 when compared to upstream Reference Location 534. This trend did not appear to be related to station power production since it was reported for two years before operation began, as well as after station operation began.



STIMULATION/INHIBITION RECORDED FOR ENTRAINMENT STUDIES AT COOPER NUCLEAR STATION, 1974 TO 1977.

SOURCE: REFERENCE DOCUMENT NUMBER 12.

Figure 3-3
SEASONAL MEAN EFFECTS OF CONDENSER PASSAGE ON PHYTOPLANKTON INHIBITION

COOPER NUCLEAR STATION

Table 3-5. Percent Composition by Location of Major Phytoplankton Taxa (>10 Percent of the Total Phytoplankton) in 7 Hour Entrainment Samples, Cooper Nuclear Station, January to December 1976

Date/Taxon	Location		
	Intake	Discharge	3*
January 26			
Stephanodiscus minutus	24.2	21.2	16.2
Asterionella formosa	16.1	11.1	14.0
Nitzschia palea	6.7	10.8	6.2
February 23			
Cyclotella meneghiniana	14.7	19.7	7.4
Stephanodiscus invisitatus	11.3	4.3	9.3
Stephanodiscus minutus	2.8	2.5	11.7
Fragilaria construens	19.4	24.5	5.4
Navicula cryptocephela	1.9	1.8	23.3
March 8			
Cyclotella atomus	10.6	10.6	0.0
Stephanodiscus minutus	35.8	45.8	40.4
Asterionella formosa	18.1	14.2	20.9
April 19			
Stephanodiscus minutus	56.6	56.0	54.9
Fragilaria pinnata	7.5	9.1	11.9
May 26			
Asterionella formosa	2.8	13.3	5.0
Fragilaria construens	69.3	10.5	66.3
F. construens v. binodis	2.0	0.0	10.7
Nitzschia acicularis	3.4	18.9	1.8
June 29			
Cyclotella meneghiniana	25.4	19.8	26.7
Stephanodiscus minutus	18.4	15.7	21.8
Fragilaria capucina	11.2	19.0	10.0

Table 3-5. Percent Composition by Location of Major Phytoplankton Taxa (>10 Percent of the Total Phytoplankton) in 7 Hour Entrainment Samples, Cooper Nuclear Station, January to December 1976 (Continued, Page 2 of 2)

Date/Taxon	Location		
	Intake	Discharge	3*
July 19			
Cyclotella atomus	11.0	7.4	7.7
C. meneghiniana	36.2	33.1	23.7
Stephanodiscus minutus	6.5	7.6	10.4
Stephanodiscus sp.	4.9	6.4	12.4
August 16			
Cyclotella atomus	8.1	15.3	7.4
C. meneghiniana	27.6	16.5	32.7
C. pseudostelligera	14.5	16.8	8.9
September 13			
Cyclotella atomus	8.3	10.3	13.7
C. meneghiniana	4.3	16.2	11.9
C. pseudostelligera	10.9	17.3	17.8
Stephanodiscus sp.	14.9	5.0	2.1
Nitzschia sp.	13.6	3.6	5.3
October†			
November 15			
Cyclotella pseudostelligera	27.6	31.3	22.7
Asterionella formosa	25.5	22.1	23.6
December 28			
Asterionella formosa	23.6	22.8	15.9
Fragilaria construens	10.1	3.1	2.9
F. pinnata	0.7	15.3	4.8
Nitzschia palea	10.5	7.0	10.1

* See Figure 3-1.
† No samples collected.

Source: Reference Document Number 11.

Table 3-6. Percent Composition by Location of Major Phytoplankton Taxa (>10 Percent of the Total Phytoplankton) in 7 Hour Entrainment Samples, Cooper Nuclear Station, January to December 1977

Date/Taxon	Location		
	Intake	Discharge	3*
January 17			
<u>Asterionella formosa</u>	73.1	60.0	+
<u>Navicula minuscula</u>		12.1	
February 14			
<u>Asterionella formosa</u>	87.5	84.1	86.7
March 21			
<u>Cyclotella meneghiniana</u>	22.3	25.1	34.5
<u>Stephanodiscus invisitatus</u>	12.5	13.1	3.9
<u>Fragilaria construens</u>	12.1	11.6	10.9
April 26			
<u>Stephanodiscus astraea</u>	7.1	7.3	10.4
<u>Stephanodiscus invisitatus</u>	8.6	12.1	16.0
<u>Asterionella formosa</u>	19.6	23.6	26.5
<u>Fragilaria construens</u>	21.2	12.4	6.0
May 24			
<u>Stephanodiscus invisitatus</u>	10.3	5.2	3.8
<u>Fragilaria capucina</u>			21.1
<u>Fragilaria construens</u>	15.1	9.1	19.2
<u>Fragilaria pinnata</u>	11.5	15.6	6.2
June 20			
<u>Cyclotella atomus</u>	7.2	10.8	14.4
<u>Cyclotella meneghiniana</u>	19.6	14.8	13.6
<u>Stephanodiscus invisitatus</u>	6.5	10.3	8.5
<u>Fragilaria construens</u>	11.1	11.2	26.5
<u>Nitzschia palea</u>	11.8	6.3	3.3
July 27			
<u>Cyclotella atomus</u>	9.4	14.4	14.1
<u>Cyclotella meneghiniana</u>	22.4	17.2	30.5

Table 3-6. Percent Composition by Location of Major Phytoplankton Taxa (>10 Percent of the Total Phytoplankton) in 7 Hour Entrainment Samples, Cooper Nuclear Station, January to December 1977 (Continued, Page 2 of 2)

Date/Taxon	Location		
	Intake	Discharge	3*
July 27 (continued)			
Stephanodiscus invisitatus	3.7	2.9	10.0
Nitzschia palea	14.1	12.3	11.4
August 16			
Cyclotella atomus	8.9	8.0	11.2
Stephanodiscus minutus	11.4	14.9	8.3
Fragilaria construens	10.4	1.2	12.1
September 12			
Cyclotella meneghiniana	10.8	5.6	6.4
Microsiphona potamos	4.4	7.7	11.4
Stephanodiscus invisitatus	14.4	10.3	11.1
Stephanodiscus minutus	13.2	15.4	13.7
Fragilaria construens	7.6	11.1	11.3
October 31			
Cyclotella atomus	17.9	24.5	16.9
Stephanodiscus hantzschii	12.8	16.9	8.3
Stephanodiscus invisitatus	10.6	8.3	12.9
Stephanodiscus minutus	10.2	13.3	10.9
November 28			
Stephanodiscus minutus	41.8	52.6	52.4
Fragilaria construens	13.0	0.9	7.5
December 5			
Cyclotella meneghiniana	19.4	19.0	18.1
Stephanodiscus invisitatus	9.7	9.3	12.5
Stephanodiscus minutus	21.0	28.7	23.6
Fragilaria construens	16.4	6.8	12.7

*See Figure 3-1
+Samples not collected.

Source: Reference Document Number 12.

Table 3-7. Percent Composition by Location of Major Phytoplankton Taxa (>10 Percent of the Total Phytoplankton) in 7 Hour Entrainment Samples, Cooper Nuclear Station, January to June 1978

Date/Taxon	Location		
	Intake	Discharge	3*
January 24			
Stephanodiscus hantzschii	19.2	14.0	10.3
Stephanodiscus invisitatus	14.7	10.4	6.4
Asterionella formosa	44.8	54.0	46.7
February 28			
Asterionella formosa	53.1	55.1	50.5
Fragilaria construens	16.2	10.1	18.2
March 30			
Stephanodiscus invisitatus	19.8	23.5	22.0
Cyclotella meneghiniana	13.4	18.5	14.4
Fragilaria construens	14.9	12.1	24.2
April†			
May 23			
Stephanodiscus invisitatus	50.5	46.4	41.2
Cyclotella meneghiniana	11.0	12.4	10.5
Asterionella formosa	10.5	9.9	13.6
June 12			
Stephanodiscus invisitatus	29.3	38.4	46.9
Stephanodiscus hantzschii	17.8	12.4	12.0
Asterionella formosa	8.0	10.7	8.4

* See Figure 3-1.
† Samples not collected.

Source: Reference Document Number 13.

Table 3-8. Species Diversity Indices of Periphyton Collected from Artificial Substrates Near Cooper Nuclear Station, 1973 to 1978

Date	Location					
	RM534	Discharge	RM532	RM530	RM528	RM526
June 1973	3.20	----	2.13	2.91	*	3.02
July 1973	3.36	----	2.64	2.78	2.55	2.03
August 1973	2.73	----	3.32	3.04	2.86	0.95
September 1973	2.61	----	1.90	3.39	2.80	2.89
October 1973	----	----	1.89	2.83	1.76	3.16
November 1973	----	----	2.90	3.14	----	----
†June 1974	2.78	----	2.38	1.50	2.16	1.92
July 1974	0.25	----	1.78	2.46	0.44	----
August 1974	2.61	----	----	2.49	2.25	----
September 1974	----	----	1.71	2.29	1.62	----
October 1974	----	----	0.39	0.37	0.28	----
November 1974	1.31	----	2.53	2.66	3.15	2.65
June 1975	2.68	----	4.21	2.63	2.67	3.17
July 1975	1.75	----	----	2.56	0.80	----
August 1975	----	----	----	----	0.70	----
September 1975	----	----	----	----	----	----
October 1975	----	----	----	----	1.32	----
December 1975	3.17	----	----	----	1.55	----
June 1976	----	2.00	----	----	----	**
July 1976	1.89	1.54	1.18	----	----	
August 1976	2.04	1.45	1.98	1.54	1.26	
September 1976	1.17	1.97	3.41	2.39	2.38	
October 1976	2.54	1.83	2.35	----	2.15	
November 1976	3.12	3.01	1.58	----	2.84	

Table 3-8. Species Diversity Indices of Periphyton Collected from Artificial Substrates Near Cooper Nuclear Station, 1973 to 1978 (Continued, Page 2 of 2)

Date	Location					
	RM534	Discharge	RM532	RM530	RM528	RM526
June 1977	2.95	2.25	----	1.49	1.61	
July 1977	2.79	1.19	1.87	2.76	1.74	
August 1977	0.40	1.42	2.02	1.49	1.79	
September 1977	----	1.59	----	1.68	----	
October 1977	----	1.61	0.58	0.90	2.60	
November 1977	2.81	2.45	1.02	2.42	----	
June 1978	1.81	2.70	1.75	----	1.34	
July 1978	----	----	----	----	----	
August 1978	2.27	1.70	1.35	----	2.88	
September 1978	----	2.43	----	1.27	1.33	
October 1978	2.17	2.42	1.98	2.54	2.26	
November 1978	2.76	1.75	2.85	2.04	----	

* Missing data.
† Station operation began.
** Location not sampled after 1975.
RM River Mile

Source: ESE, Compiled from Reference Document Numbers 8, 9, 10, 11, 12, and 13.

Table 3-9. Mean Biomass Production Per Day (mg/m^2 Per Day--Ash-Free Dry Weight) at Periphyton Sampling Locations in the Missouri River Near Cooper Nuclear Station, 1972 to 1978

Year	Location				
	RM534	RM532	RM530	RM528	RM526
1972	278.17(5)*	290.96(4)	225.68(5)	285.46(4)	109.30(1)
1973	145.79(4)	194.49(6)	198.80(6)	152.63(4)	120.49(5)
1974	159.06(4)	409.57(5)	531.89(6)	428.30(6)	255.52(2)
1975	149.27(2)	188.53(1)	122.91(2)	182.61(5)	56.71(1)
1976	287.93(5)	354.96(5)	272.80(2)	134.48(4)	--†
1977	88.44(4)	225.63(3)	105.70(6)	58.42(5)	--
1978	107.67(5)	503.54(1)	758.15(3)	735.38(3)	

* Number in parentheses () indicates the number of months used to calculate the mean average.

† Location RM 526 was eliminated from the sampling program in 1976.

RM River Mile

Source: Reference Document Numbers 12 and 13.

Periphytic algal community composition was dominated by diatoms throughout the monitoring program (see Table 3-10). As noted previously, few differences were detected for the first two years of the monitoring program. However, in 1976 when the discharge canal was sampled, a shift in species composition was noted. The shift involved two species of the diatom genera Navicula. During the summer period of highest absolute temperatures, one species (N. luzonensis) replaced another (N. tripunctata var. schizonemoides) as the dominant in the discharge canal. During 1977, this diatom species was again dominant in the discharge and relatively abundant at a location approximately 2.5 miles downstream from the discharge.[12] Based on the example of Navicula spp, the discharge of Cooper Nuclear Station may have slightly altered the natural distribution of the river periphyton community. For example, water temperatures above 30°C (86°F) have been regarded as unfavorable for many diatom species.[15]

These types of influence are not unique to Cooper Nuclear Station and have been demonstrated for a number of power plants nationwide. At Cooper Nuclear Station, both phytoplankton and periphyton communities seem to display a temporary alteration in July and August, but recover in fall, thus making the station's impacts of short duration over a limited area. These impacts are considered to be minor in terms of system effect.

3.4.1.2 Zooplankton--Duplicate zooplankton samples were collected monthly (May through November). Samples were collected with a Miller high-speed plankton sampler. Sampling locations are presented in Figure 3-4. In addition, zooplankton was sampled at the intake, discharge, and 7,500 feet downstream of the discharge. These samples were collected with a modified Icanberry sampler to determine mortality due to station entrainment. Cooper Nuclear Station entrained an estimated 0.9 to 6.5 percent of the river zooplankton annually from 1974 through 1977 (see Table 3-11). This calculation was based on plant usage and the assumption of zooplankton homogeneity in the Missouri River.[16]

Table 3-10. Common Periphyton Taxa (Based on Abundance or Biovolume+) by Year Occurring on Artificial Substrates in the Missouri River Near Cooper Nuclear Station, 1972 to 1978

	Year						
	1972	1973	1974	1975	1976	1977	1978
Bacillariophyta							
Achnanthes lanceolata	x	-*	-	x†	-	-	-
Asterionella formosa		-		x	-	-	-
Biddulphia laevis	x	x	x	x	x	x	x
Cocconeis diminuta	x	-	-		-	-	
C. pediculus	-	x	x	x	-	-	-
C. placentula (and varieties)	x	x	x	x	x	x	-
Cyclotella meneghiniana			-	x		-	-
Cyclotella sp.			-	x		-	x
Diatoma vulgare	-	-	x	x	x	-	x
Fragilaria brevistriata (and varieties)	-	-	-			x	-
F. capucina		-	x		-		
F. construens (and varieties)	-	x	x	x	-	x	-
F. pinnata	x	-	x				
Gomphonema angustatum	x	-	-				
G. bohemicum	x	x	-			-	
G. intricatum					x	x	
G. olivaceum	x	x	x	x	x	-	x
G. parvulum	x	x	x	x	x	x	x
Gomphonema sp.**	-		x	x	-	-	x
Melosira granulata	-	-	x	x	-	-	-
M. varians	-	x	x	-	-	-	-
Navicula cryptocephala	x	-	-	-	-	-	-
N. graciloides††	x		-	-			
N. luzonensis***				x	x	x	x
N. radiosa (and varieties)	-	-	x	-	-	-	-
Navicula sp.	-	-	-	x	-	x	-
N. tripunctata	-	-	-	x	-	-	
N. tripunctata var. schizonemoides†††	x	x	x	x	x	x	x
N. viridula	-	x	-	-	-	-	-
N. vitabunda	x	-	-				
Nitzschia acicularis	x	-	x	-	-	-	-
N. dissipata	x	-	x	-	x		-
N. filiformis	x	-	-			x	
N. palea	-	x	x				-
Nitzschia sp.	-	-	x	x	x	x	x
N. tryblionella	x	-	-	-			

Table 3-10. Common Periphyton Taxa (Based on Abundance or Biovolume+) by Year Occurring on Artificial Substrates at Periphyton Sampling Locations in the Missouri River Near Cooper Nuclear Station, 1972 to 1978 (Continued, Page 2 of 2)

	Year						
	1972	1973	1974	1975	1976	1977	1978
Pleurosigma sp.	-		-	x		-	
Rhoicosphenia curvata	x	-	x	-	x	-	-
Stephanodiscus sp.			x	x	-	-	x
Synedra sp.			-	x	-	-	
Chlorophyta							
Cladophora glomerata	x	x	-				
Cladophora sp.****	-		x	-	x	x	x
Oedogonium sp.	-	x	-			x	
Spirogyra sp.			x	x	x		
Stigeoclonium tenue		x					
Stigeoclonium sp.††††	-		-	x	x	x	x
Cyanophyta							
Lyngbya sp.			x		x	x	x
Oscillatoria sp.					x	-	x
Plectonema notatum	-	x	-				
*Schizothrix calcicola******	x						
TOTAL	19	15	24	23	16	15	14

+ Composed 5 percent or more.

* Present, but not considered common (-).

† Common (x).

** Included *G. intricatum* in 1974 and 1975.

†† May have included *N. tripunctata* var. *schizonemoides* in 1972.

*** Identified as *N. biconica* in 1975.

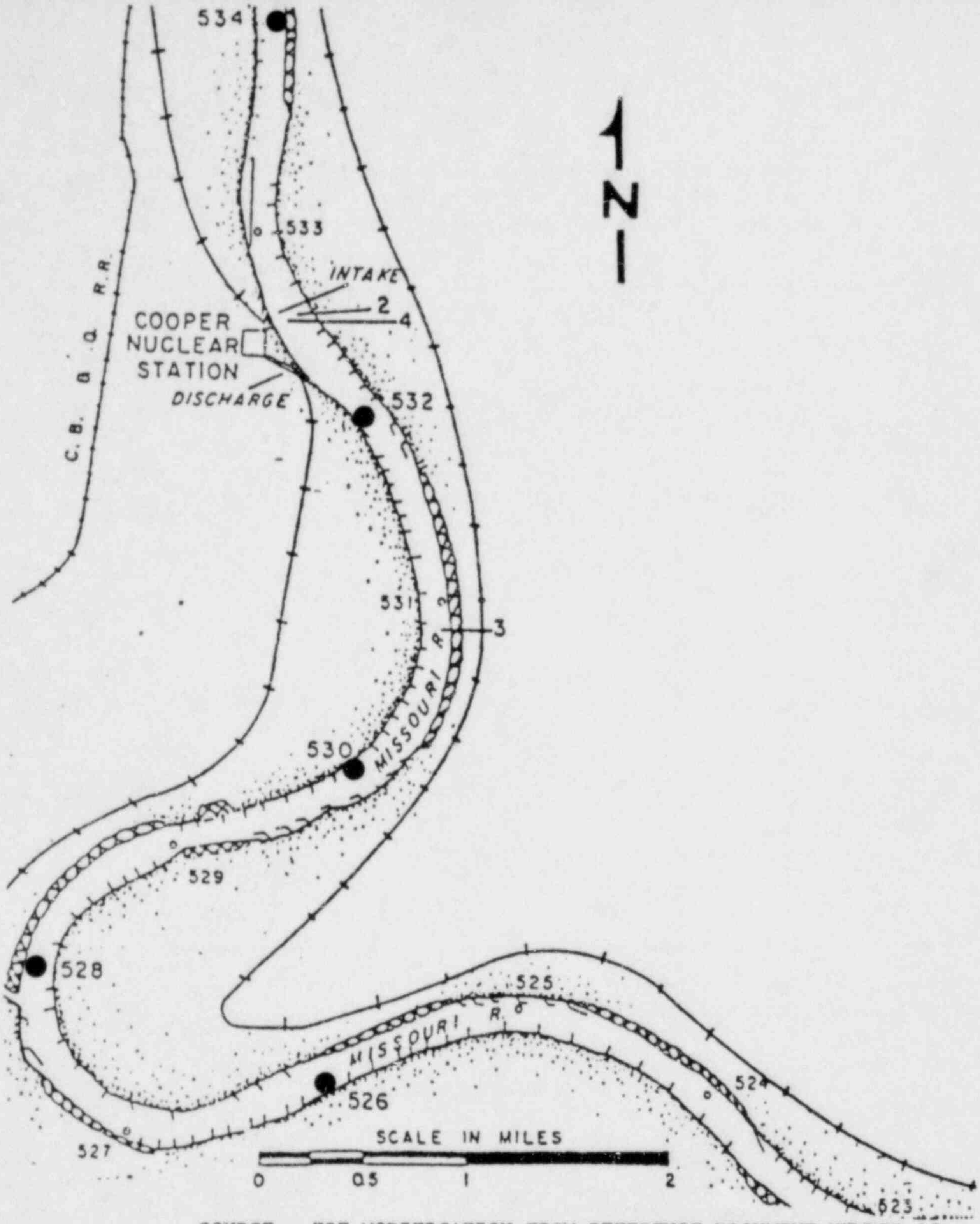
††† Identified as *N. heufleri* during 1972 to 1975.

**** May include *C. glomerata*.

†††† Probably growth forms of *S. tenue*.

***** May include *Lyngbya* sp.

Source: Reference Document Number 13.



SOURCE: ESE MODIFICATION FROM REFERENCE DOCUMENT NUMBER 13.

Figure 3-4
ZOOPLANKTON SAMPLING LOCATIONS

COOPER NUCLEAR STATION

Table 3-11. Estimates of Zooplankton Entrainment at Cooper Nuclear Station, 1974 to 1977

Date	Discharge Temperature C°	ΔT	Percent River Water Entrained	Percent River Zooplankton Entrained
03-20-74	6.3	1.8	2.14	2.1
04-24-74	16.2	0.0	1.62	1.6
05-22-74	23.0	2.5	1.47	1.4
06-19-74	32.0	7.5	1.81	1.8
07-31-74	31.3	5.3	2.93	2.9
08-07-74	31.5	8.7	2.91	2.9
09-25-74	27.0	9.0	2.97	2.9
10-17-74	21.4	8.9	2.93	2.9
11-20-74	17.0	10.0	3.96	3.9
12-02-74	10.3	8.8	6.50	6.5
01-06-75	13.4	13.4	4.98	4.9
02-03-75	12.8	12.2	3.22	3.2
03-03-75	15.5	13.5	4.31	4.3
04-10-75	17.0	11.5	2.41	2.4
05-08-75	26.1	8.6	1.62	1.6
06-24-75	27.5	7.5	0.99	0.9
07-11-75	32.6	5.6	1.97	1.9
07-31-75	35.8	8.4	2.31	2.3
08-01-75	35.4	8.6	2.28	2.2
09-26-75	21.0	5.0	1.66	1.6
11-21-75	13.9	7.9	1.90	1.9
12-29-75	17.0	16.0	3.66	3.6
01-29-76	22.0	21.0	2.5	2.5
02-20-76	21.9	18.6	1.8	1.8
03-08-76	15.4	15.0	2.2	2.2
04-15-76	28.0	14.0	1.7	1.7
05-27-76	24.5	6.5	2.2	2.2
06-25-76	31.5	10.1	1.7	1.7
07-27-76	35.0	8.0	2.6	2.6
08-29-76	34.0	9.0	2.7	2.7
09-16-76	29.0	7.5	2.7	2.7
11-22-76	16.5	13.0	2.6	2.6
12-28-76	24.0	24.0	3.0	3.0

Table 3-11. Estimates of Zooplankton Entrainment at Cooper Nuclear Station, 1974 to 1977 (Continued, Page 2 of 2)

Date	Discharge Temperature C°	ΔT	Percent River Water Entrained	Percent River Zooplankton Entrained
01-21-77	20.0	20.0	5.4	5.4
02-16-77	17.0	17.0	4.4	4.4
03-21-77	17.5	12.5	4.6	4.6
04-28-77	25.0	7.5	2.8	2.8
05-31-77	28.6	6.7	2.6	2.6
06-27-77	35.1	8.8	4.0	4.0
07-20-77	37.5	10.5	4.0	4.0
08-30-77	32.0	8.0	4.0	4.0
09-13-77	29.9	9.3	3.0	3.0
10-27-77	20.8	8.9	2.8	2.8
11-28-77	15.2	14.9	3.6	3.6
12-20-77	18.2	17.8	4.3	4.3
Mean Entrainment			2.9	

Source: ESE, Compiled from Reference Document Numbers 9, 10, 11, and 12.

As an average through time (4 years), the plant entrained 2.9 percent of the river zooplankton. This grand mean, however, is probably low since during 1977 there was a trend toward greater water usage as the station operated at higher turbine capacity (>84 percent on 8 of 12 sampling periods).[12] Thus, an average calculated for 1977 only indicated that 3.7 percent of the river zooplankton was entrained by Cooper Nuclear Station. This may represent a worst-case situation.

A summary of total zooplankton mean densities (number/m^3) was compiled (see Table 3-12) in an effort to determine trends in abundances, i.e., upstream versus downstream. Inspection of these data indicated a frequent reduction in densities below the station compared to the upstream reference. However, there was almost an equal number of occasions when downstream densities were equal to, or greater than, those reported at the reference station. Comparisons of species diversity indicies were similarly ambiguous with regard to station effect (see Table 3-13).

Species composition has apparently remained consistent and no major shifts in group dominance (i.e., Copepoda versus Cladocera versus Rotifera) occurred other than expected seasonal shifts[17] (see Figures 3-5, 3-6, and 3-7).

Sampling to assess the effects of mechanical damage to zooplankton was conducted in 1973 prior to thermal loading.[8] In this study, and subsequent investigations at Cooper Nuclear Station indicated recovery for some portion of the entrained organisms. This assumption was based on observations made at 0 hours and 4 hours after collection. In recent reviews,[19,18] wide ranges in mortalities for zooplankton have been reported. As noted by Schubel, et al.,[18] many zooplankters possess complex but delicate appendages that are involved in a variety of functions. Damage to these appendages then may alter normal function and lead to subsequent death. For this assessment, 100 percent mortality is assumed since latent effects due to appendicular damage would not necessarily be obvious after 4 hours of observation.

Table 3-12. Summary of Total Zooplankton Mean Density ($Number/m^3$) 1973 Through 1978

Date	Location				
	RM534	RM532	RM530	RM528	RM526
May 1973	4,782	2,090	2,561	2,302	2,404
June 1973	2,295	2,250	2.833	2,439	2,671
July 1973	1,978	1,973	2,537	1,964	1,872
August 1973	1,235	1,486	1,417	1,290	1,570
September 1973	240	225	250	377	238
October 1973	229	282	276	283	245
November 1973	809	621	1,004	543	673
May 1974	8,755	8,954	6,861	3,787	18,001
June 1974	7,880	6,970	6,066	4,342	3,039
*July 1974	6,048	4,815	3,162	4,519	4,112
August 1974	4,698	4,481	3,949	2,492	3,904
September 1974	482	584	371	553	738
October 1974	1,426	1,310	759	1,344	1,078
November 1974	3,421	4,719	3,045	3,833	3,195
May 1975	10,556	11,755	12,971	9,294	11,212
June 1975	6,465	6,511	7,668	6,259	7,383
July 1975	1,509	1,843	1,821	1,652	1,434
August 1975	452	445	513	499	500
September 1975	431	413	429	409	533
October 1975	418	527	458	496	352
November 1975	2,530	3,313	3,306	2,358	3,147
May 1976	4,459	4,489	3,261	†	†
June 1976	2,200	2,380	2,315		
July 1976	1,656	1,520	1,782		
August 1976	916	1,533	835		
September 1976	1,200	1,026	1,241		
October 1976	378	387	322		
November 1976	3,826	3,460	3,120		

Table 3-12. Summary of Total Zooplankton Mean Density (Number/m^3) 1973 Through 1978 (Continued, Page 2 of 2)

Date	Location				
	RM534	RM532	RM530	RM528	RM526
May 1977	4,103	3,845	5,867		
June 1977	6,041	4,503	4,372		
July 1977	5,134	3,221	4,942		
August 1977	3,907	3,729	4,615		
September 1977	871	767	900		
October 1977	326	373	360		
November 1977	5,772	4,440	21,335		
May 1978	49,454	28,316	30,370		
June 1978	4,168	6,268	8,708		
**					

* Plant operation began.
† Sampling discontinued at these locations.
** Sampling discontinued.
RM River Mile.

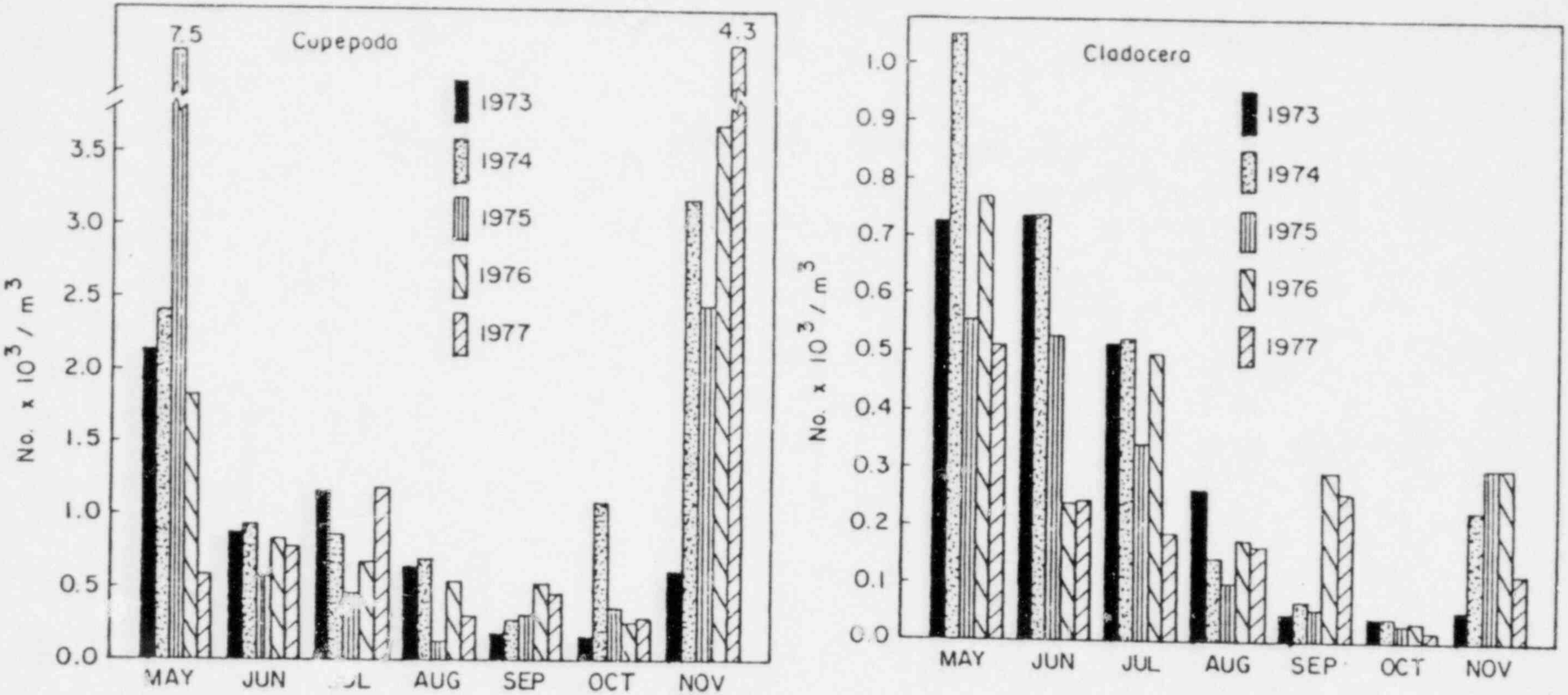
Source: ESE, Compiled from Reference Document Numbers 8, 9, 10, 11, 12 and 13.

Table 3-13. Species Diversity Indices for Zooplankton Collected from the Missouri River Near Cooper Nuclear Station, 1974 to 1978

Date		Diversity Index			Evenness Index			Number of Taxa		
		RM534	RM532	RM530	RM534	RM532	RM530	534	532	530
May	1974	1.47	2.08	1.65	0.32	0.50	0.37	23	18	22
	1975	2.25	2.39	2.30	0.48	0.49	0.50	25	29	24
	1976	3.41	3.22	3.30	0.74	0.72	0.73	24	22	23
	1977	1.38	1.30	1.23	0.30	0.30	0.30	24	22	18
June	1974	1.20	1.35	1.28	0.28	0.31	0.32	20	20	16
	1975	2.00	1.88	1.92	0.42	0.41	0.40	28	24	27
	1976	2.78	2.88	2.58	0.61	0.67	0.61	23	20	19
	1977	1.77	1.96	1.86	0.40	0.42	0.42	20	25	22
July	1974	0.94	1.06	1.55	0.31	0.37	0.50	21	18	22
	1975	3.04	2.97	2.96	0.57	0.54	0.52	41	47	52
	1976	3.41	3.54	3.55	0.75	0.78	0.78	23	23	23
	1977	1.60	1.82	1.64	0.38	0.42	0.39	19	20	19
August	1974	0.60	0.85	0.92	0.20	0.26	0.29	21	27	25
	1975	3.08	3.09	2.96	0.58	0.57	0.55	39	43	41
	1976	3.51	3.36	3.48	0.76	0.72	0.75	25	25	25
	1977	0.87	0.68	0.87	0.22	0.16	0.20	16	19	20
September	1974	2.00	1.69	1.97	0.64	0.62	0.71	23	15	16
	1975	3.84	3.92	3.78	0.77	0.78	0.79	32	33	29
	1976	3.22	3.19	3.29	0.72	0.73	0.74	22	21	22
	1977	3.40	3.38	3.29	0.74	0.70	0.71	24	28	25
October	1974	0.90	1.05	0.97	0.31	0.37	0.37	18	17	14
	1975	3.56	3.64	3.67	0.67	0.69	0.69	39	39	39
	1976	3.30	3.55	3.35	0.70	0.76	0.71	26	26	26
	1977	1.86	2.45	2.04	0.45	0.86	0.47	19	21	21

RM River Mile

Source: Reference Document Numbers 12 and 13.

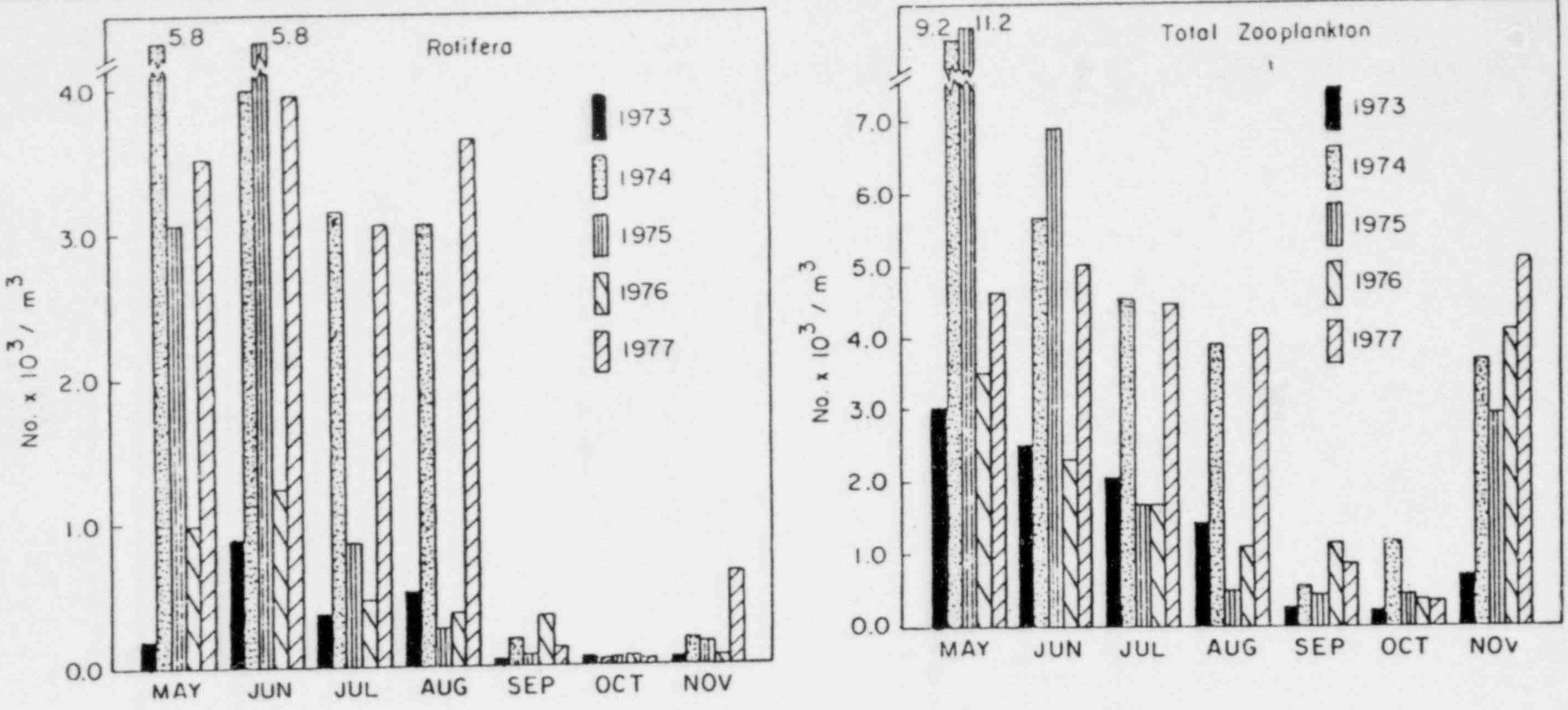


SAMPLES COLLECTED NEAR COOPER NUCLEAR STATION,
MAY TO NOVEMBER 1973-1977.

SOURCE: REFERENCE DOCUMENT NUMBER 12.

Figure 3-5
MEAN MONTHLY ABUNDANCE OF COPEPOD AND CLADOCERAN ZOOPLANKTERS

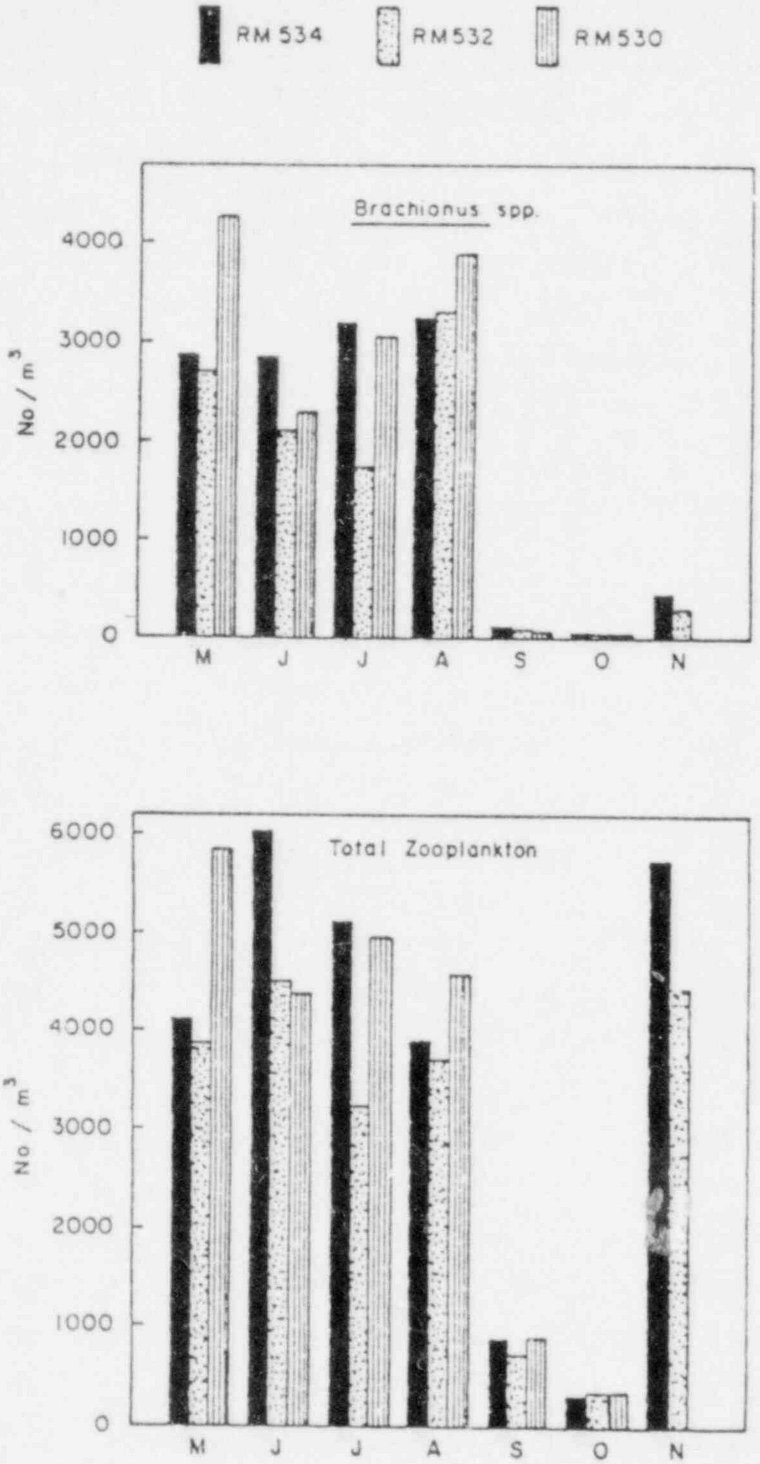
COOPER NUCLEAR STATION



SAMPLES COLLECTED NEAR COOPER NUCLEAR STATION, MAY-NOVEMBER, 1973-1977.
SOURCE: REFERENCE DOCUMENT NUMBER 12.

Figure 3-6
MEAN MONTHLY ABUNDANCE OF ROTIFERS AND TOTAL ZOOPLANKTON

COOPER NUCLEAR STATION



COLLECTIONS TAKEN FROM THREE LOCATIONS IN THE MISSOURI RIVER NEAR COOPER NUCLEAR STATION, MAY TO NOVEMBER 1977 SOURCE: REFERENCE DOCUMENT NUMBER 12.

Figure 3-7
COMPARISON OF DENSITIES OF DOMINANT ZOOPLANKTON TAXA AND TOTAL ZOOPLANKTON

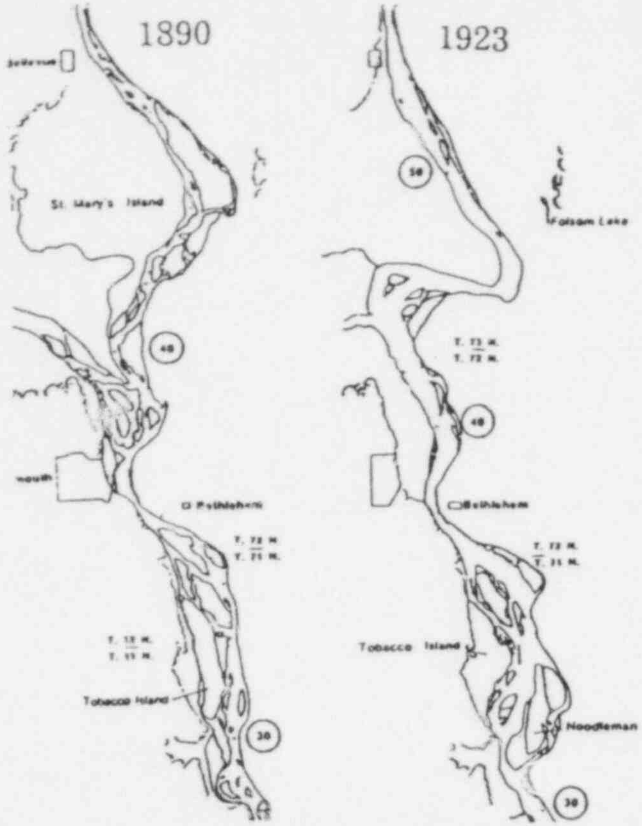
COOPER NUCLEAR STATION

Because of making the assumption of 100 percent mortality, losses estimated by this report are higher than previously reported. Entrainment studies at the Yankee Station on the Connecticut River indicated nearly 100 percent mortality of cladocerans and copepods at 31°C to 39.4°C.[20] Apparently these water temperatures exceed the tolerance limits for the majority of the organisms comprising these two groups. The discharge temperature at Cooper Nuclear Station equaled or exceeded 31°C (87.8°F) on 12 of the 45 sampling dates or 26 percent of the time from 1974 through 1977. Therefore, mechanical and, at times, thermal stress have acted concurrently to entrain the Missouri River zooplankton by a varying percentage that ranged from less than 1 percent to slightly over 6 percent (see Table 3-11).

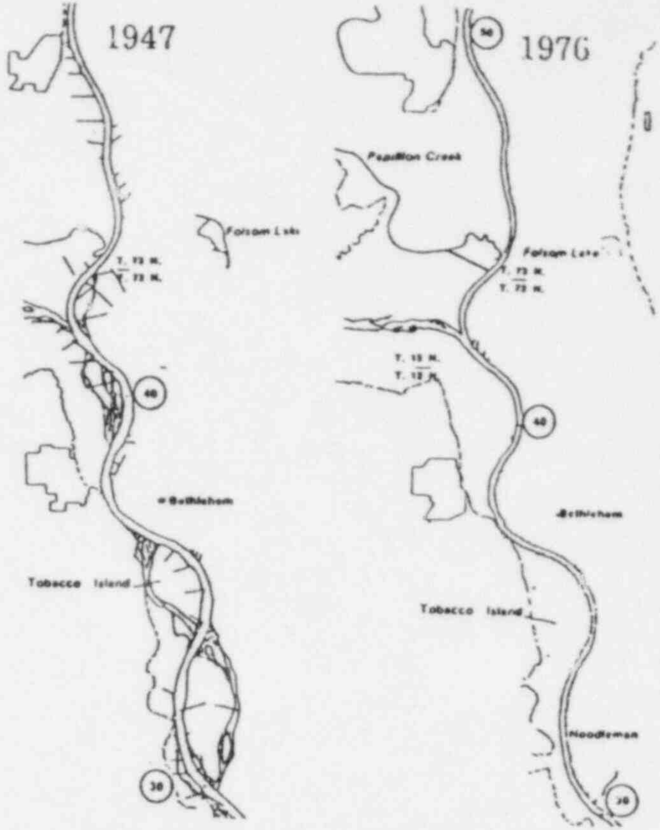
The effects on zooplankton appear to be localized. It may be argued that the plankters killed by station operation are not lost to the system but, as noted by Heinle,[19] the route these materials (damaged plankters) take through the system is probably changed.

3.4.1.3 Benthic Macroinvertebrates--Main stream impoundments and channelization, in particular have profoundly affected the benthic habitat of the Missouri River near Cooper Nuclear Station. This habitat alteration has undoubtedly affected the diversity distribution and densities of benthic macroinvertebrates in the affected portions of the river. An example of this habitat alteration is shown schematically in Figure 3-8.[21] It should be noted, however, that even before this major habitat alteration occurred, the Missouri River's silt load was believed to form a faunal barrier for freshwater mussels at the point of confluence with the Mississippi River.[22,23] The present river in the channelized reaches can be described as, "a serpentine, self-cleaning navigation channel characterized by high water velocities (4.2 fps at 35 to 40,000 cfs navigation flows)."[21]

Productive habitats for benthic macroinvertebrates in the Missouri River are limited and usually confined to protected areas around or behind



Habitat diversity in the form of islands, side channels, slack water and the corridor of riparian vegetation have been sacrificed. Number in circle indicates river mileage above the Iowa/Missouri State Line.



Habitat diversity in the form of islands, side channels, slack water and the corridor of riparian vegetation have been sacrificed. Number in circle indicates river mileage above the Iowa/Missouri State Line.

SOURCE: REFERENCE DOCUMENT NUMBER 21.

Figure 3-8
MISSOURI RIVER AT NEBRASKA CITY, NEBRASKA BETWEEN 1890 AND 1976

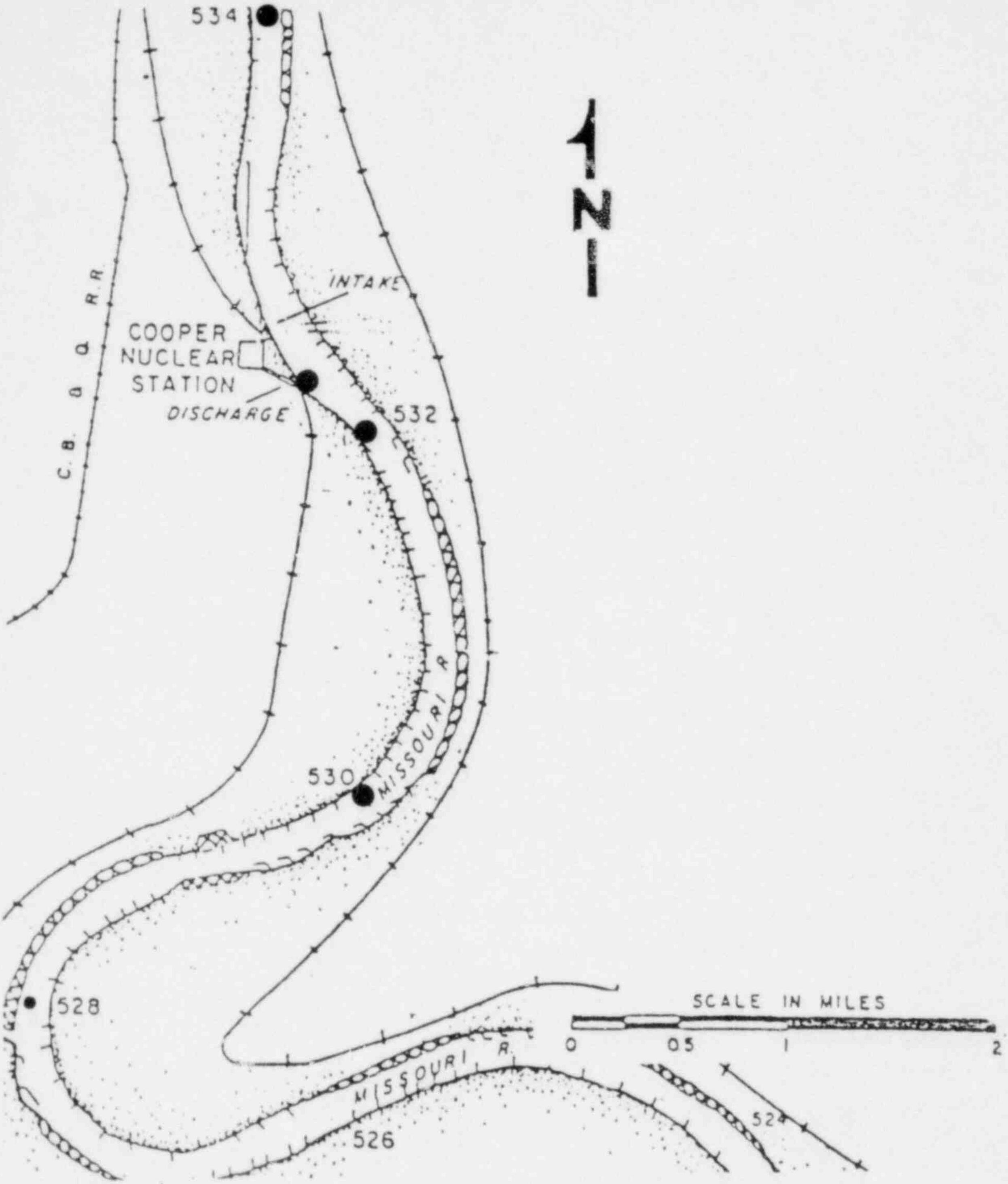
COOPER NUCLEAR STATION

the various river training structures. These habitats have been sampled for benthic invertebrates near Cooper Nuclear Station by several methods.

Sampling locations are presented in Figure 3-9. Data on the benthic community were available for 1969 through June 1974 (preoperational) and July 1974 through 1978 (operational). These data sets were collected with a Ponar grab sampler. Rock-filled samplers were used from 1972 through 1974 but were replaced by multiple plate samplers in 1975. The rock basket samplers were abandoned because the numerous problems associated with this device were recognized. Briefly, these samplers are subjected to varying amounts of siltation. The surface area of the sample is generally not known. Depending upon position and stream characteristics, they can be subjected to varying water levels. Between replicate variability can often be as great or greater as between station variability. Because of these limitations, the data reviewed was restricted to Ponar samples (1973 to 1978) and multiplate sampling (1975 to 1978). This sampling was conducted on three occasions annually and generally represented the late spring or early summer (June and July); late summer (August and September); and fall (October and November).

The number of taxa reported from natural substrates has varied from a low of 40 in 1973 to 68 in 1976. The number of taxa reported from multiple plate samplers has varied little (71 in 1978, 87 in 1976) and probably reflects the more uniform habitat provided by these sampling devices.[24] The species composition reported from both natural and artificial substrates is typical of large midwestern streams. It did not include the introduced Asiatic clam Corbicula fluminea which is increasingly being found associated with heated discharges.[25]

Because of the high variability in the natural substrate data, analyses were limited to those components believed to most likely demonstrate station-related effects. Numerous literature sources (e.g., Coutant,[26] Proffitt,[27] Benda and Proffitt,[28]), have indicated



SOURCE: ESE MODIFICATION FROM REFERENCE NUMBER 13.

Figure 3-9
BENTHOS SAMPLING LOCATIONS

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that in general benthic community response to thermal additions can usually be detected by changes in species diversity indices, species or group elimination, or enhanced populations of tolerant species.

Inspection of the summarized species diversity data from natural substrate collections, ranked by season, indicate some trends (see Table 3-14). In general, diversity was lower at Location 532 (discharge) compared to the upstream reference (534) during the June to August periods. When ranked by year (see Table 3-15), diversity appeared to increase at the discharge location during October. In two out of four comparable years, however, the station was shut down during October (1975 and 1976). When ranked annually (see Table 3-14), wide gaps between collecting periods are also more apparent and a great deal of caution must be exercised in using these data.

Because of the limitations of habitat and sampling device, benthic community description and collections were restricted to areas downstream of wing dams and other structures.

Substrates collected from these habitats ranged from sand to silt (see Table 3-16). The numerically dominant organisms from these areas were oligochaetes and chironomids. Of these two groups, oligochaete densities usually accounted for the greatest majority of the organisms collected. A summary of benthic densities (see Table 3-17) indicated that densities downstream of Cooper Nuclear Station were almost always higher than the upstream reference location (534), and may be related to station operation. As noted previously, oligochaetes (Tubificidae) comprised the majority of the community. Studies by Langford and Aston[29] have shown that some species of tubificids may respond in a positive manner to thermal additions. This response indicates that tubificids (Limnodrilus hoffmeisteri in particular) would be included in the tolerant group whose populations are enhanced by thermal additions as noted previously. Total tubificid densities were plotted and are presented in Figure 3-10.

Table 3-14. Benthic Macroinvertebrate Diversity Indices* Calculated from Ponar Grab Samples Collected from the Missouri River Near Cooper Nuclear Station, 1973 to 1978 Ranked By Season

Date	Location			
	RM534	RM532	RM530	RM528
June 21, 1973	2.26†	2.75	2.16	2.23
June 25, 1974	1.27	1.72	2.16	1.50
July 10, 1975	2.63	1.32	1.50	1.27
June 22, 1977	1.60	0.75	1.68	1.31
June 26, 1978	2.49	1.84	----**	----
August 24, 1973	1.46	1.97	1.95	1.45
August 13, 1974	1.92	1.98	2.13	2.46
August 28, 1975	1.82	1.57	1.85	----
August 06, 1976	2.62	2.70	2.50	2.91
August 11, 1977	2.73	2.59	2.39	1.59
August 15, 1978	3.18	----	3.29	----
October 18, 1973	----	1.25	1.41	1.58
October 01, 1974	1.65	2.04	1.86	2.14
October 16, 1975	2.31	2.80	2.19	1.30
September 23, 1976	2.01	2.44	2.33	2.16
October 15, 1976	2.37	2.49	2.52	2.58
October 06, 1977	2.19	2.01	2.42	2.29
October 10, 1978	3.07	3.06	----	----

* Shannon (1948), log base 2.
† Mean of three replicates.
** Insufficient sample size.

Source: ESE, Modification from Reference Document Numbers 12 and 13.

Table 3-15. Benthic Macroinvertebrate Diversity Indices Calculated from Ponar Grab Samples Collected from the Missouri River Near Cooper Nuclear Station, 1973 to 1978 Ranked By Year

Date	Location			
	RM534	RM532	RM530	RM528
June 21, 1973	2.26	2.75	2.16	2.23
August 24, 1973	1.46	1.97	1.95	1.45
October 18, 1973	----*	1.25	1.41	1.58
June 25, 1974	1.27	1.72	2.16	1.50
August 13, 1974	1.92	1.98	2.13	2.46
October 01, 1974	1.65	2.04	1.86	2.14
July 10, 1975	2.63	1.32	1.50	1.27
August 28, 1975	1.82	1.57	1.85	----
October 16, 1975	2.31	2.80	2.19	1.30
August 06, 1976	2.62	2.70	2.50	2.91
September 23, 1976	2.01	2.44	2.33	2.16
October 15, 1976	2.37	2.49	2.52	2.58
June 22, 1977	1.60	0.75	1.68	1.31
August 11, 1977	2.73	2.59	2.39	1.59
October 06, 1977	2.19	2.01	2.42	2.29
June 26, 1978	2.49	1.84	----	----
August 15, 1978	3.18	----	3.29	----
October 10, 1978	3.07	3.06	----	----

* Insufficient Sample Size.

Source: ESE, Compiled from Reference Document Number 13.

Table 3-16. Total Organic Carbon (mg/kg) and Texture of Sediments Sampled With Ponar Grab From the Missouri River Near Cooper Nuclear Station, 1973 to 1978

Collection Date	Location							
	RM 534		RM 532		RM 530		RM 528	
	TOC	Texture	TOC	Texture	TOC	Texture	Mean	Texture
June 21, 1973	6,500	Silt	1,277	Sand	11,000	Clay	1,633	Clay
June 15, 1974	14,000	Clay	15,667	Clay	13,000	Clay	7,767	Silt
July 10, 1975	4,283	Silt	5,867	Silt/Clay	11,233	Clay/Silt	5,200	Silt
August 6, 1976	6,433	Silt	12,667	Clay	11,667	Clay	6,633	Silt
June 22, 1977	11,700	Clay	9,500	Clay/Muck	18,000	Clay/Muck	4,500	Muck/Silt
June 26, 1978	13,667	Clay/Muck	12,333	Clay/Muck	14,000	Clay/Muck	10,266	Clay/Muck
August 24, 1973	1,733	Sand	11,000	Clay	12,333	Clay	5,467	Silt
August 13, 1974	10,233	Clay	20,667	Muck	12,667	Clay	9,867	Clay/Silt
August 28, 1975	8,517	Silt/Clay	7,067	Silt	10,733	Clay	657	Sand
September 23, 1976	7,683	Silt	8,500	Silt	13,166	Clay	5,533	Silt
August 11, 1977	8,567	Clay	7,667	Clay/Muck	14,667	Clay/Muck	5,333	Muck/Silt
August 15, 1978	6,9[illegible]	Clay/Muck	15,333	Clay/Muck	14,333	Clay/Muck	5,633	Sand/Muck
October 18, 1973	783	Sand	9,467	Silt	8,033	Silt	7,867	Silt
October 01, 1974	1,300	Sand	3,967	Silt/Sand	13,333	Clay	10,000	Clay
October 16, 1975	3,267	Silt	11,000	Clay	5,800	Silt/Clay	5,933	Silt/Clay
November 15, 1976	8,783	Silt	7,967	Silt	11,667	Clay	4,400	Silt/Sand
October 06, 1977	9,567	Clay/Muck	8,567	Clay/Muck	6,433	Clay/Sand	6,800	Clay/Muck
October 10, 1978	4,233	Sand/Muck	6,900	Sand/Muck	5,033	Sand/Muck	900	Sand/Muck

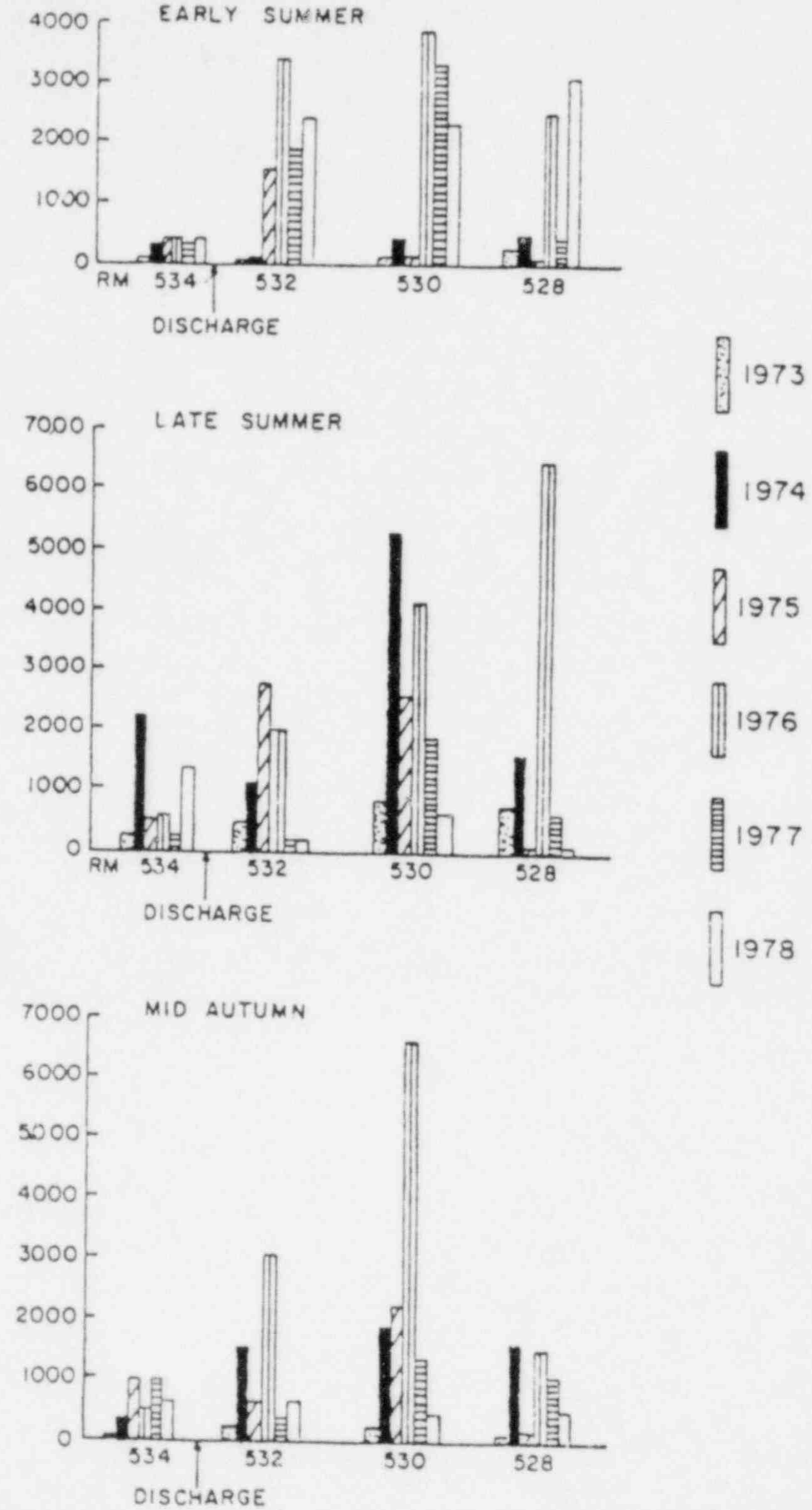
Source: ESE, Modification from Reference Document Number 13.

Table 3-17. Benthic Densities (Number/m^2) Calculated from Ponar Grab Samples Collected from the Missouri River near Cooper Nuclear Station, 1973 to 1978

Collection Date	Location			
	RM 534	RM 532	RM 530	RM 528
21 June 1973	315*	124	296	597
25 June 1974	1133	464	622	302
10 July 1975	440	1618	127	106
22 June 1977	416	2003	4822	517
26 June 1978	1046	3370	4101	5979
24 August 1973	265	704	932	832
13 August 1974	2494	1625	5564	2084
28 August 1975	372	2646	2690	44
06 August 1976	536	4325	5223	3005
11 August 1977	340	599	2029	781
15 August 1978	1537	208	1046	359
18 October 1973	12	221	321	56
01 October 1974	416	1612	3533	1844
16 October 1975	857	1254	2236	176
23 October 1976	428	2155	4731	6640
15 November 1976	605	5172	14496	1594
06 October 1977	1008	334	1468	680
10 October 1978	743	882	359	391
1973 mean	198	353	519	491
1974 mean	1355	1241	3257	1419
1975 mean	559	1849	1693	110
1976 mean	523	3903	8150	3746
1977 mean	588	979	2606	660
1978 mean	1109	1487	1835	2243

* Mean of three replicates.

Source: ESE, 1981.



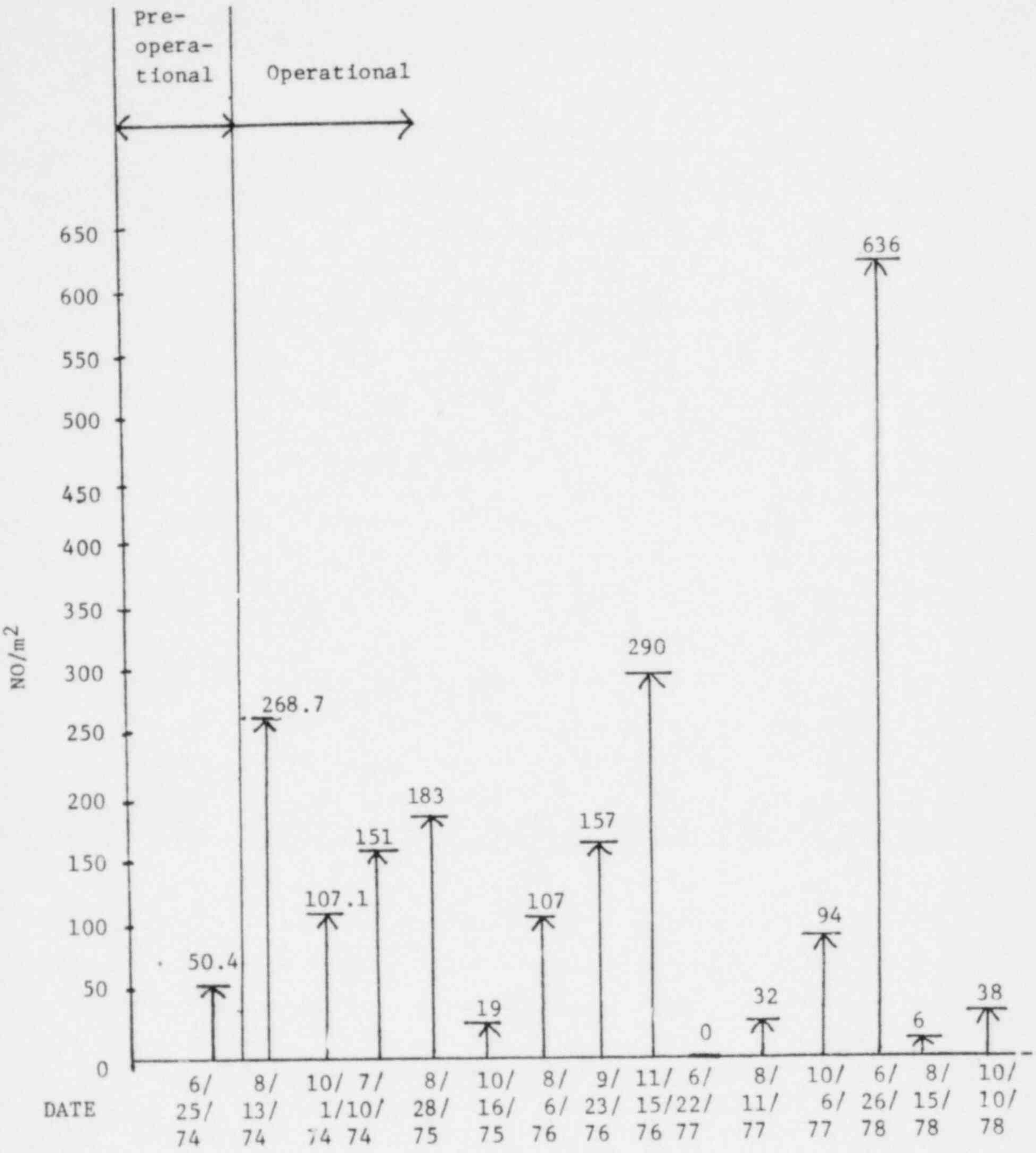
SOURCE: REFERENCE DOCUMENT NUMBER 13

Figure 3-10
MEAN DENSITIES (NO/M²) OF TOTAL TUBIFICIDAE AT BENTHIC SAMPLING LOCATIONS, 1973 THROUGH 1978

COOPER NUCLEAR STATION

Before attempting to interpret Figure 3-10, Langford and Aston's findings should be briefly recounted in light of the present data. The majority of tubificids collected near Cooper Nuclear Station were classified as immature individuals that lacked capilliform chaeta. An examination of the species list for Cooper Nuclear Station revealed that there were four species of tubificids that produce young that would be so described, i.e., without capilliform chaeta. These were all members of the genus Limnodrilus (L. cervix, L. claparedianus, L. spiralis and L. hoffmeisteri). Experimentally, Langford and Aston determined a seven-fold increase in cocoon production for L. hoffmeisteri held at 20°C vs. 10°C. It is however, unknown if other members of this genus would respond in a similar manner. Another recognized factor or variable controlling tubificid populations is the bacterial concentrations of the substrate. A crude measure of the potential food available is the concentration of Total Organic Carbon (T.O.C.) in the substrates (see Table 3-16). As noted by Brinkhurst, however, one needs to know the quantity of usable material arriving at the substrate. In the absence of this information, the total (T.O.C.) is probably of little significance. Regardless of this one question, the data depicted by Figure 3-10 demonstrate a striking trend of increased production of tubificids downstream from Cooper Nuclear Station after operation began. Nichols[31] has reported a similar but more localized response from a South Carolina reservoir.

A further refinement of this trend was attempted by plotting densities of mature Limnodrilus hoffmeisteri (see Figure 3-11). Although similar to the general trend described for total tubificid densities, the upstream-downstream differences were less convincing and differences in adult densities are not considered conclusive. Finally, Langford and Aston were unsure whether the differences they noted were in direct response to temperature by the oligochaetes or if the effect was on the bacteria on which the worms feed. Rankin, et. al.,[32] for example, determined that there was a qualitative shift in the population of heterotrophic mesophilic bacteria below a power station on the



SOURCE: ESE, 1981.

Figure 3-11
MEAN DENSITIES FOR LIMNODRILUS HOFFMEISTERI AT LOCATION 532, 1974 THROUGH 1978

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Connecticut River. Although the question of mode [i.e., temperature or temperature and bacteria or some other factor(s)] remains open, the presence of a station-related effect as demonstrated by increased tubificid densities does seem a reasonable conclusion. This increased production is probably of some benefit since tubificids are increasingly being recognized as important food items for some fish.[33,34]

Analysis of artificial substrate data was concentrated on the last two years of operational monitoring. These data were deemed the most appropriate to demonstrate the effects of, or lack of, the thermal discharge of Cooper Nuclear Station.

Summaries of diversity indicies were too fragmented, because of missing data, to produce any meaningful results (see Table 3-18). Comparisons of densities (see Table 3-19) and community composition (see Figure 3-12) indicated that densities of macroinvertebrates, with the exception of June 1977, were higher in the discharge canal by factors ranging from 3 to 21 times than those reported from Reference Location 534 (see Table 3-19). Community composition was similar between these two locations in June and August but in October chironomids and naidid oligochaetes occupied a greater proportion of the community in the discharge canal. A shift in dominance such as this is not unexpected. An unusual point in this data is noted for the August 1977 data. Hourly temperature data was obtained from NPPD for the month of July 1977 and summarized (see Table 3-20). These data were used to assess the thermal regime in the discharge canal for the majority of the time period preceeding collection. The average temperature during this period was 34.7°C (94.5°F) with temperatures of 37.7°C (100°F) occurring for several hours. Temperatures this high are generally considered detrimental to most nearctic species, yet densities from the discharge canal were 3 times those from the reference location. A forthright explanation for this situation cannot be made at this time.

In summary, a general stimulation of the benthic community was noted. Few statistically significant differences, however, were noted.[8,13] Station-related effects appeared minor and usually localized.

Table 3-18. Macroinvertebrate Diversity Indices* Calculated from Artificial Substrate Collections in the Missouri River near Cooper Nuclear Station, 1975 to 1978

Collection Date	Location				
	RM 534	Discharge Canal	RM 532	RM 530	RM 528
10 July 1975	---**		---	1.78	2.30
22 June 1977	1.87	2.17	---	---	2.36
26 June 1978	2.49	1.46	1.84	---	---
28 August 1975	3.52		---	2.52	2.70
06 August 1976	3.28		3.87	3.22	---
11 August 1977	3.24	3.22	3.24	3.44	3.62
15 August 1978	3.18	2.83	---	3.29	---
16 October 1975	3.57		---	2.91	2.80
23 September 1976	3.30		2.96	3.31	3.22
15 November 1976	3.58		3.70	---	---
06 October 1977	---	2.88	---	3.17	2.90
10 October 1978	3.07	3.31	3.06	---	---

* Shannon (1948), log base 2.
** Samplers lost.

Source: ESE Modification from Reference Document No. 13

Table 3-19. Densities (Number/m^2), Diversity, Number of Taxa and Families Colonizing Artificial Substrate at River Reference Location versus the Discharge Canal, 1977 to 1978

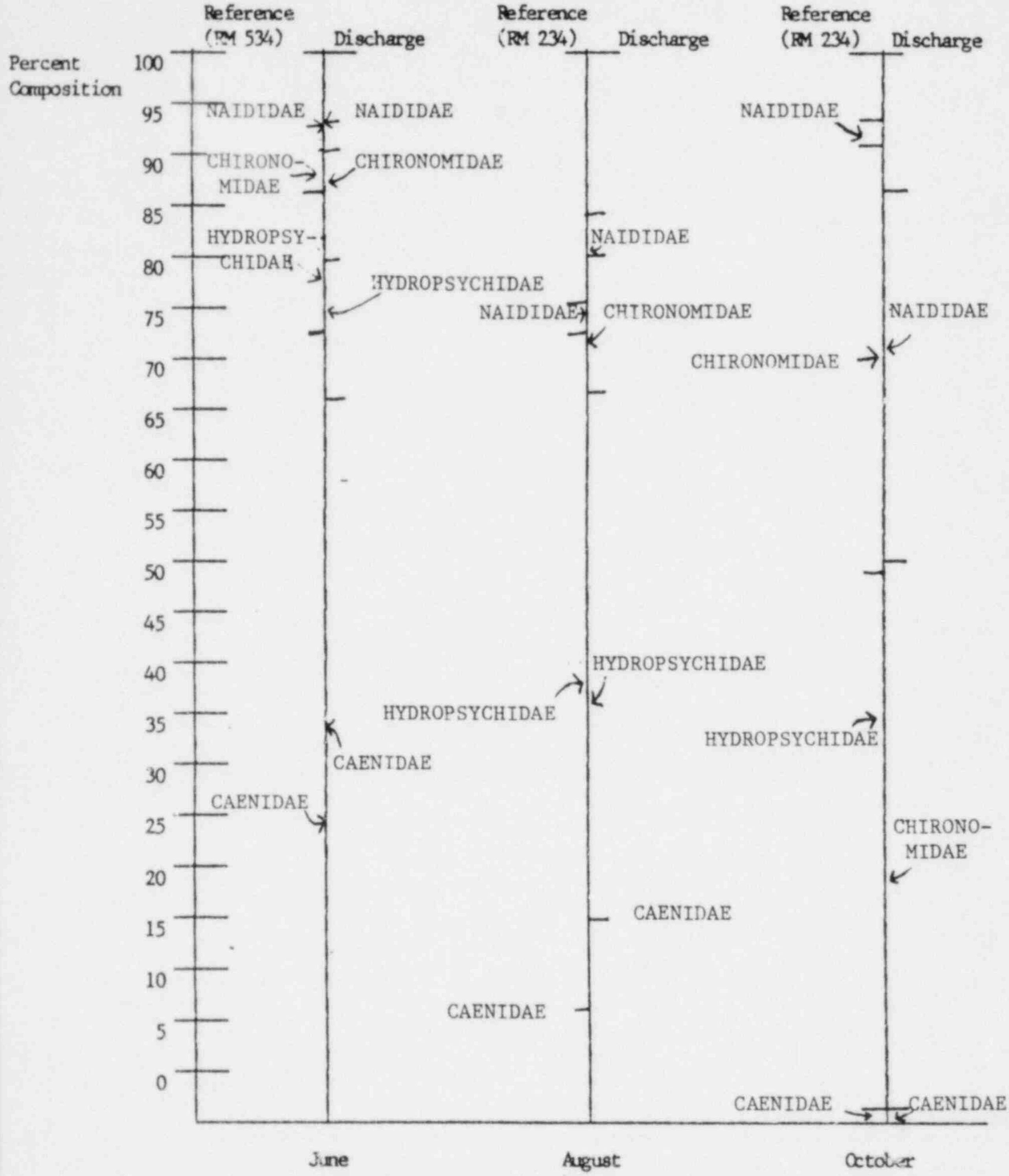
Date	Taxa	Location: Reference RM(534)	Location: Discharge
22 June 1977	Naididae	575	960
	Caenidae	46320	36540
	Heptageniidae	380	780
	Baetidae	2660	1275
	Hydropsychidae	8415	8190
	Chironomidae	3520	6640
	Total	63385	55240
	Diversity	1.87	2.17
	Number of Taxa	40	41
11 August 1977	Naididae	35	1
	Caenidae	315	2570
	Heptageniidae	520	920
	Baetidae	680	1460
	Hydropsychidae	2975	8275
	Chironomidae	540	2515
	Total	5140	16025
	Diversity	3.24	3.22
	Number of Taxa	29	30
06 October 1977	Naididae	---*	7815
	Caenidae		150
	Heptageniidae		1540
	Baetidae		25
	Hydropsychidae		2145
	Chironomidae		11150
	Total		23070
	Diversity		2.88
	Number of Taxa		52

Table 3-19. Densities (Number/m^2), Diversity, Number of Taxa and Families Colonizing Artificial Substrate at River Reference Location versus the Discharge Canal, 1977 to 1978 (Continued, Page 2 of 2)

Date	Taxa	Location Reference (RM534)	Discharge
26 June 1978	Naididae	35	515
	Caenidae	565	20695
	Heptageniidae	55	65
	Baetidae	5	90
	Hydropsychidae	350	1790
	Chironomidae	60	1585
	Total	1165	25215
	Diversity	2.49	1.46
	Number of Taxa	18	36
15 August 1978	Naididae	25	30
	Caenidae	1005	7570
	Heptageniidae	390	680
	Baetidae	245	530
	Hydropsychidae	915	3645
	Chironomidae	305	2658
	Total	3595	15380
	Diversity	3.18	2.83
	Number of Taxa	30	34
10 October 1978	Naididae	620	7745
	Caenidae	160	295
	Heptageniidae	2585	2820
	Baetidae	340	600
	Hydropsychidae	3175	12665
	Chironomidae	11065	10785
	Total	18630	35250
	Diversity	3.07	3.31
	Number of Taxa	42	50

* Samples Lost
RM River Mile

Source: ESE compilied from Reference Document No. 12, 13.



SOURCE: ESE, 1981.

Figure 3-12
PERCENT COMPOSITION OF MACROINVERTEBRATE COMMUNITIES FROM ARTIFICIAL SUBSTRATES

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Table 3-20. Daily and Month-Long Temperature Summary of Cooper Nuclear Station's Intake and Discharge Canal, July 1977

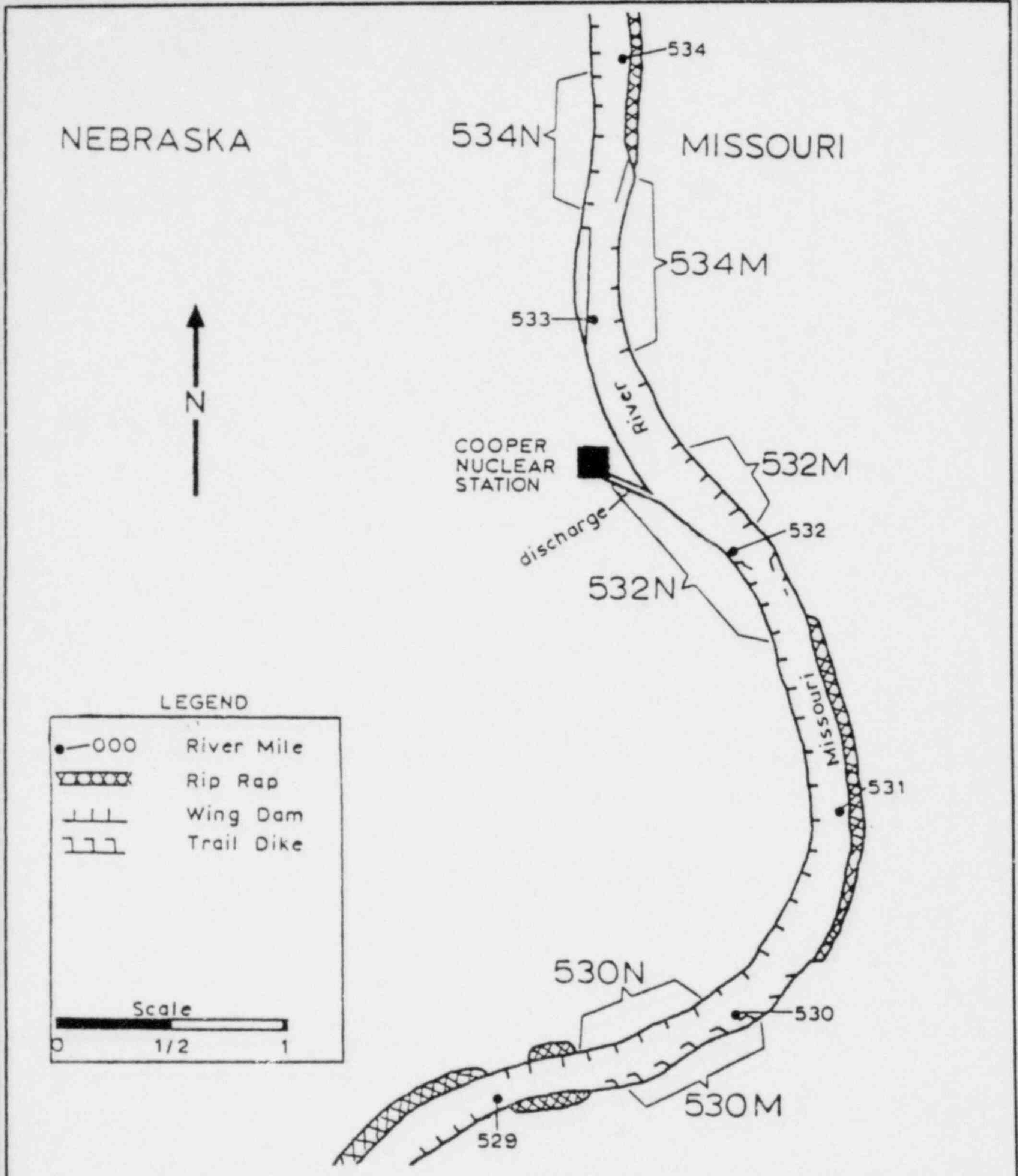
Date	Minimum °F	Hours of Continuous Duration	Maximum °F	Hours of Continuous Duration	24 Hour Means		
					Discharge °F	Inlet °F	ΔT °F
7-1-77	91.0	2	95.5	2	93.4	76.5	16.9
2	89.5	7	91.0	3	90.1	76.3	13.8
3	89.0	2	95.5	1	92.6	76.6	16.0
4	94.0	2	97.5	6	96	77.5	18.5
5	94.0	1	99	2	95.9	78.0	17.9
6	93.0	3	95.5	8	94.3	79.0	15.3
7	95.5	14	96.0	5	95.7	80.3	15.4
8	95.0	2	96.5	5	95.8	80.5	15.3
9	88.0	7	91.5	1	89.0	79.9	9.1
10	89.0	7	90	8	89.5	79.3	10.2
11	89.5	5	91.5	8	90.4	78.8	11.6
12	91.0	4	94	4	92.3	78.8	13.5
13	93.5	8	95.5	3	94.2	79.1	15.1
14	95	10	97.5	8	96.1	79.4	16.7
15	94.5	1	100	1	96.4	80.5	15.9
16	95.5	5	97.5	4	96.3	80.5	15.8
17	96	6	97	12	96.6	80.8	15.8
18	95	4	99	1	97.2	79.5	17.7
19	94.5	6	100	4	96.7	79.5	17.2
20	96	10	101	2	97.8	81.1	16.7
21	97.5	5	103	2	98.0	81.8	16.2
22	96	7	97	4	96.4	80.8	15.6
23	94.5	3	96.5	5	95.6	80.1	15.5
24	95	8	97	5	95.8	80.7	15.1
25	94	1	96	4	95.4	80.2	15.2
26	94	8	96	5	94.7	79.7	15.0
27	90	1	93.5	7	92.0	79.7	12.3
28	93	2	95.5	3	94.1	79.7	14.4
29	92.5	1	95.5	6	94.2	77.5	16.7
30	92	5	94.5	7	93.5	78.4	15.1
31	92.5	1	94.5	9	93.8	79.0	14.8

Source: ESE Compiled from NPPD Data

3.4.1.4 Fish--Fisheries collections near Cooper Nuclear Station consisted of electroshocking and shoreline seine hauls. Sampling locations are indicated in Figure 3-13. Samples were collected monthly from May through November

Fish of the Missouri River are expected to be attracted to Cooper Nuclear Station's outfall during the cold months (see Figure 3-13). This was substantiated by the fact that catch per effort (CPE) and diversity of fish collected at the discharge during periods of station operation were greater than those found at the same location during nonoperational periods, at least during the fall when the water temperature was low (see Table 3-21). Gizzard shad and carp were the most notable examples among all species investigated. These findings are not surprising and were reported for several species in other power plant outfalls by several investigators.[20]

Fish are known to congregrate in regions of thermal plume during colder months. This has been documented for a variety of species including gizzard shad[35] and adult carp.[36] Fish have also been shown to avoid heated plumes when plume temperature exceeds fish preferred temperature.[36] Fish are attracted to heated effluents of power plants in winter and fall months, and although this could lead to cold shock, result in increased metabolism, and decreased growth, it may be beneficial in certain instances. Working on the Potomac Electric Power Company Station in Maryland, Moore and Frisbie[37] concluded that during the 4-month survey (January to April), the heated effluent of the plant supported winter sport fisheries at a time when no fisheries existed on the main river channel. Elser[38] reported that heated effluents yielded substantially more fish per effort during all seasons except July to September when water temperature was relatively high.



SOURCE: REFERENCE DOCUMENT NUMBER 13.

Figure 3-13
FISH SAMPLING LOCATIONS IN THE VICINITY OF COOPER NUCLEAR STATION, MAY-NOVEMBER 1978

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Table 3-21. Total Catch Per Effort (CPE) by Location from the Missouri River Near Cooper Nuclear Station, 1975 to 1977

	LOCATION						
DATE	RM534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
May 1975	28.0	40.6	108.0	60.0	30.0	66.0	31.0
June 1975	21.0	47.0	63.0	38.0	14.1	44.0	34.6
July 1975	24.0	15.6	105.0	40.5	35.8	51.0	30.2
August 1975	22.6	3.5	9.0	8.0	7.5	29.0	11.7
September 1975	20.4	24.0	87.5	34.5	45.0	34.0	32.3
October 1975	20.4	22.0	125.0	19.0	15.0	46.0	15.6
November 1975	12.0	22.5	255.0	21.6	31.5	39.0	13.0
May 1976	40.5	84.0	216.0	75.0	39.6	86.7	68.8
June 1976	58.8	56.0	57.0	58.8	22.8	54.0	30.0
July 1976	66.0	41.7	30.0	33.6	14.4	33.6	51.0
August 1976	62.0	111.4	48.0	50.4	42.0	54.0	29.1
September 1976	26.0	45.0	144.0	76.5	22.0	34.0	25.0
October 1976	44.0	48.0	27.0	58.8	10.8	51.4	8.0
November 1976	*	72.0	123.0	61.5	56.4	18.0	17.0
May 1977	35.0	80.0	48.0	72.0	58.0	55.0	19.0
June 1977	25.0	42.0	9.0	30.0	31.0	10.0	14.0
July 1977	21.0	31.0	24.0	43.0	20.0	21.0	13.0
August 1977	37.0	54.0	60.0	24.0	33.0	59.0	17.0
September 1977	35.0	76.0	63.0	69.0	23.0	61.0	19.0
October 1977	25.0	68.0	81.0	52.5	61.0	52.0	21.0
November 1977	24.0	23.0	81.0	16.5	40.0	19.0	7.0

* Location not sampled

Source: ESE, 1981.

Both preoperational (1973 and early 1974) and operational (late 1974 to 1978) data indicated changes in relative abundance of gizzard shad, river carpsucker, and goldeye. However, all these species were dominant in the vicinity of the station during the preoperational and operational period (see Tables 3-22 and 3-23). The number of species did not differ remarkably during the same periods. Furthermore, the seasons of the greatest abundance for at least the top five dominant species in the area were similar for the preoperational and operational periods.

The density of major species found in the study area was compared for preoperational and operational periods. Electroshocking data collections indicated that gizzard shad, goldeye, carp, and river carpsucker were the most abundant species in the study area (see Table 3-22). In general, densities and CPE for these species were higher in 1976 than in most other years (see Table 3-24). Statistical comparisons among years also demonstrated this trend, particularly for the June and August sampling periods (see Table 3-25).

Shoreline seine collections indicated the nearshore community to be dominated by the western silvery and plains minnows; emerald, river, red, and sand shiners (see Table 3-23). A general decline in abundance was evident for populations of red and sand shiners. It should be noted that shoreline seining in the Missouri River is subject to rather rigorous variables and this apparent decline may be a sampling artifact.

When comparing CPE at discharge and reference stations, Cooper Nuclear Station seems to alter the distribution pattern of some species seasonally (see Table 3-26). In particular, gizzard shad and carp were most frequently found in the discharge during the early spring (May) and fall (September to November) sampling periods. This apparent concentration phenomenon may or may not always be related to thermal attraction. For example, CPE for the discharge canal in October 1975 was higher than for any other area sampled. During this time period Cooper Nuclear Station was not operating, suggesting that some

Table 3-22. Number and Relative Abundance of Fish Collected by Electroshocking in the Missouri River Near Cooper Nuclear Station, 1973 to 1978

Species	1973		1974		1975		1976		1977		1978	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Shovelnose sturgeon	0	0.0	0	0.0	0	0.0	7	0.3	14	0.9	3	0.3
Paddlefish	1	<0.1	0	0.0	1	<0.1	0	0.0	1	<0.1	1	0.1
Longnose gar	3	0.2	2	0.1	5	0.4	8	0.4	12	0.8	5	0.5
Shortnose gar	29	1.6	30	2.1	13	1.0	23	1.1	18	1.2	24	2.5
American eel	0	0.0	0	0.0	3	0.2	0	0.0	2	0.1	1	0.1
Skipjack herring	0	0.0	2	0.1	0	0.0	6	0.3	6	0.4	0	-
Gizzard shad	305	17.1	284	20.0	312	24.2	490	23.2	299	19.2	237	29.9
Goldeye	104	5.8	77	5.4	91	7.1	224	10.6	197	12.7	103	10.6
Rainbow smelt	0	-	0	-	0	-	0	-	0	-	5	0.5
Northern pike	4	0.2	5	0.4	0	0.0	2	0.1	1	<0.1	0	-
Carp	331	18.6	391	27.5	260	20.2	557	26.4	276	17.7	217	21.7
Goldfish	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0	0	-
Silvery minnow	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	1	0.1
Silver chub	0	0.0	0	0.0	0	0.0	0	0.0	4	0.2	0	-
Creek chub	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1	0	-
Blue sucker	1	<0.1	0	0.0	0	0.0	0	0.0	2	0.1	3	0.3
River carpsucker	525	29.5	267	18.8	387	30.0	519	24.6	467	30.0	135	14.7
Quillback	0	0.0	1	<0.1	3	0.2	5	0.2	2	0.1	1	0.1
Smallmouth buffalo	12	0.7	20	1.4	10	0.8	15	0.7	7	0.4	2	0.2
Bigmouth buffalo	24	1.3	8	0.6	17	1.3	20	0.9	5	0.3	12	1.4
Shorthead redhorse	2	0.1	1	<0.1	2	0.1	8	0.4	4	0.2	1	0.1
Black bullhead	15	0.8	0	0.0	0	0.0	3	0.1	0	0.0	0	-
Channel catfish	20	1.1	39	2.7	17	1.3	24	1.1	45	2.9	24	2.5
Flathead catfish	12	0.7	8	0.6	9	0.7	7	0.3	22	1.4	11	1.1
White bass	11	0.5	18	1.3	20	1.6	25	1.2	15	1.0	18	1.9
Green sunfish	8	0.4	7	0.5	0	0.0	3	0.1	1	<0.1	0	-
Pumpkinseed	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	-

Table 3-22. Number and Relative Abundance of Fish Collected by Electroshocking in the Missouri River Near Cooper Nuclear Station, 1973 to 1978 (Continued, Page 2 of 2)

Species	1973		1974		1975		1976		1977		1978	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Orangespotted sunfish	1	<0.1	2	0.1	1	<0.1	1	<0.1	1	<0.1	0	-
Bluegill	58	3.3	29	2.0	3	0.2	3	0.1	1	<0.1	0	-
Bluegill—green sunfish hybrid	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0	0	-
Smallmouth bass	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	-
Largemouth bass	53	3.0	40	2.8	4	0.3	6	0.3	2	0.1	1	0.1
White crappie	59	3.3	41	2.9	4	0.3	16	0.8	11	0.7	5	0.5
Black crappie	73	4.1	45	3.2	9	0.7	14	0.7	2	0.1	14	1.5
Yellow perch	0	0.0	0	0.0	1	<0.1	0	0.0	0	0.0	0	-
Sauger	52	2.9	39	2.7	29	2.2	29	1.4	52	3.3	12	1.2
Freshwater drum	75	4.2	66	4.6	88	6.8	96	4.5	86	5.5	78	8.1
TOTAL	1,781		1,423		1,289		2,113		1,556		964	

Source: Reference Document Number 13.

Table 3-23. Number and Relative Abundance of Fish Collected by Seining in the Missouri River Near Cooper Nuclear Station, 1973 to 1978

Species	1973		1974		1975		1976		1977		1978	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Shovelnose sturgen	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0
Shortnose gar	0	0.0	1	<0.1	0	0.0	0	0.0	1	<0.1	0	0.0
Skipjack herring	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0	0	0.0
Gizzard shad	170	5.2	6	0.1	7	1.2	85	7.0	17	0.8	0	0.0
Goldeye	0	0.0	0	0.0	1	0.2	0	0.0	1	<0.1	2	0.3
Rainbow smelt	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	59	7.9
Northern pike	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Carp	0	0.0	0	0.0	2	0.3	2	0.2	2	0.1	3	0.4
Silvery minnow	1,476	44.9	827	18.6	-*	0.0	-	0.0	-	0.0	-	0.0
Western silvery minnow	-	0.0	128	2.9	7	1.2	106	8.7	412	18.4	4	0.5
Plains minnow	-	0.0	1,055	23.7	52	9.1	58	4.7	293	13.1	37	5.0
Speckled chub	5	0.1	8	0.2	3	0.5	5	0.4	2	0.1	0	0.0
Sturgeon chub	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0
Flathead chub	25	0.8	26	0.6	4	0.7	10	0.8	16	0.7	0	0.0
Silver chub	70	2.1	142	3.2	20	3.5	211	17.3	194	8.7	51	6.9
Emerald shiner	381	11.6	818	18.4	229	39.8	232	19.0	83	3.7	112	15.1
River shiner	160	4.9	690	15.5	81	14.1	260	21.3	955	42.7	235	31.6
Bigmouth shiner	0	0.0	2	<0.1	10	1.7	5	0.4	0	0.0	3	0.4
Red shiner	420	12.8	396	8.9	83	14.4	85	7.0	80	3.6	115	15.5
Sand shiner	281	8.6	160	3.6	31	5.4	12	1.0	0	0.0	61	8.2
Suckermouth minnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	0.5
Fathead minnow	98	3.0	16	0.4	2	0.3	4	0.3	1	<0.1	2	0.3
Cyprinidae	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0
Carpoides sp.	0	0.0	0	0.0	4	0.7	0	0.0	0	0.0	0	0.0
River carpsucker	94	2.9	119	2.7	4	0.7	32	2.6	27	1.2	14	1.9
Quillback	0	0.0	1	<0.1	1	0.1	18	1.5	0	0.0	1	0.1

Table 3-23. Number and Relative Abundance of Fish Collected by Seining in the Missouri River Near Cooper Nuclear Station, 1973 to 1978 (Continued, Page 2 of 2)

Species	1973		1974		1975		1976		1977		1978	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
White sucker	0	0.0	2	<0.1	0	0.0	0	0.0	0	0.0	0	0.0
Smallmouth buffalo	0	0.0	9	0.2	0	0.0	21	1.7	8	0.3	0	0.0
Bigmouth buffalo	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Shorthead redhorse	1	0.1	0	0.0	0	0.0	1	<0.1	0	0.0	0	0.0
Channel catfish	40	1.2	24	0.5	14	2.4	31	2.5	62	2.8	31	4.2
Flathead catfish	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1
White perch	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
White bass	24	0.7	8	0.2	9	1.6	26	2.1	25	2.0	1	0.1
Green sunfish	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0
Orangespotted sunfish	1	<0.1	0	0.0	0	0.0	0	0.0	1	<0.1	0	0.0
Bluegill	0	0.0	1	<0.1	0	0.0	4	0.3	0	0.1	1	0.1
Largemouth bass	0	0.0	0	0.0	0	0.0	2	0.2	0	0.0	0	0.0
White crappie	9	0.3	4	0.1	1	0.1	2	0.2	4	0.2	3	0.4
Black crappie	6	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Sauger	3	<0.1	1	<0.1	6	1.0	2	0.2	3	<0.1	1	0.1
Walleye	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0
Freshwater drum	17	0.5	4	0.1	4	0.7	7	0.6	46	2.1	2	0.3
TOTAL	3,284		4,450		575		1,222		2,236		743	

* Silvery minnow separated into western silvery minnow and plains minnow after June 1974.

Source: Reference Document Number 13.

Table 3-24. Summary of Average Catch Per Unit Effort of Fish Collected by Electroshocking in the Missouri River Near Cooper Nuclear Station, 1973 to 1978*

Species	Year	Sampling Location							Total Number	Average CPE
		RM534N	RM534M	Discharge Canal	RM532N	RM532M	RM530N	RM530M		
Gizzard shad	1973	5.7	10.0	-†	16.5	1.3	11.3	6.0	305	7.3
	1974	2.5	11.7	-	17.0	1.3	12.8	2.0	284	6.8
	1975	3.1	1.9	54.0	7.4	6.0	11.2	3.2	312	8.2
	1976	12.2	19.9	21.6	12.7	3.0	14.7	3.7	490	12.5
	1977	2.3	11.1	4.7	10.5	9.7	10.3	0.7	299	7.0
	1978	8.4	3.3	67.3	1.5	3.3	2.9	0.4	287	6.8
Goldeye	1973	1.5	1.7	-	4.5	2.8	2.5	4.3	104	2.5
	1974	1.5	0.8	-	3.2	4.8	0.8	1.7	77	1.8
	1975	2.7	1.9	1.6	1.7	2.8	3.6	2.0	91	2.4
	1976	5.6	9.1	2.0	3.9	3.5	4.7	6.0	224	5.0
	1977	5.4	6.6	1.3	4.1	5.9	2.6	4.6	197	4.4
	1978	2.'	2.3	0.9	1.5	3.1	1.4	40.	103	2.4
Carp	1973	5.7	10.0	-	15.0	6.0	9.7	8.8	331	7.9
	1974	5.7	18.7	-	18.8	8.5	7.2	6.3	391	9.3
	1975	3.2	7.7	24.0	5.7	4.3	6.2	6.2	260	6.8
	1976	10.9	11.6	43.6	15.5	6.8	10.7	13.2	557	16.0
	1977	6.0	6.0	17.1	6.2	5.6	6.4	5.6	276	7.6
	1978	2.6	2.9	24.4	6.2	4.1	6.0	3.1	217	5.2
River carpsucker	1973	8.8	17.5	-	25.0	8.7	13.2	14.3	525	12.5
	1974	4.5	10.3	-	11.8	4.0	7.7	6.2	267	6.4
	1975	7.7	7.6	16.4	9.7	7.8	15.1	9.4	387	10.2
	1976	12.8	16.1	15.2	16.4	10.2	11.3	7.8	519	12.8
	1977	8.9	21.6	4.3	14.1	10.2	13.1	1.4	467	10.5
	1978	3.9	3.3	7.1	3.2	2.9	2.4	2.1	135	3.2

Table 3-24. Summary of Average Catch Per Unit Effort of Fish Collected by Electroshocking in the Missouri River Near Cooper Nuclear Station, 1973 to 1978* (Continued, Page 2 of 2)

Species	Year	Sampling Location RM534N	RM534M	Discharge Canal	RM532N	RM532M	RM530N	RM530M	Total Number	Average CPE
Freshwater drum	1973	1.2	0.8	-	3.8	2.8	2.0	1.8	75	1.8
	1974	2.5	3.5	-	2.5	1.2	0.8	0.5	66	1.6
	1975	3.0	3.3	0.9	0.9	2.2	2.8	2.1	88	2.3
	1976	2.4	1.5	4.8	2.3	4.2	2.4	0.7	96	2.6
	1977	2.4	1.9	1.3	2.4	2.3	2.0	1.7	86	2.0
	1978	0.7	2.7	3.4	1.7	1.9	2.0	0.9	78	1.9
TOTAL CPE	1973	25.0	42.3	-	83.0	25.1	43.3	35.7	1,781	42.4
	1974	18.7	48.3	-	69.7	19.7	31.3	15.6	1,423	33.9
	1975	21.2	25.0	107.5	31.7	25.6	44.1	24.1	1.289	30.6
	1976	49.3	66.2	100.4	59.3	29.6	48.4	33.4	2.113	55.2
	1977	28.9	53.4	52.1	43.9	38.0	39.6	15.7	1,556	38.8
	1978	18.6	17.3	124.3	17.6	18.3	18.9	11.6	964	23.0

* Number of fish per 30 minutes of electroshocking.
† Discharge canal data included in 532N data.
RM River Mile.

Source: Reference Document Number 13.

Table 3-25. Comparison of the Monthly Average Catch Per Effort by Electroshocking in the Missouri River Near Cooper Nuclear Station, 1973 to 1978

	Average CPE						ANOVA Results		Tukey's Multiple Comparison
	1973	1974	1975	1976	1977	1978	F Ratio*	Significance	
May	52.2	44.0	46.3	79.9	52.3	26.8	2.07	NS	-
June	27.5	33.0	36.6	47.3	23.0	13.5	3.39	$p \leq 0.05$	1976>1978
July	54.5	22.0	38.6	40.2	24.9	11.2	4.50	$p \leq 0.05$	1973>1974, 1978
August	30.8	32.8	14.3	60.5	40.4	14.8	5.04	$p \leq 0.05$	1976>1975, 1978
September	35.8	24.5	35.5	41.9	52.1	34.3	0.71	NS	
October	51.7	37.7	28.1	37.2	51.4	36.5	0.12	NS	
November	43.2	43.2	38.8	48.8	30.0	23.5	0.34	NS	

* Tabular F ratio for 95 percent confidence interval equal to 2.53.

Source: Reference Document Number 13.

Table 3-26. Total CPE and CPE of Selected Species by Location Collected from the Missouri River Near Cooper Nuclear Station, 1975 to 1977

Species	Date	Sampling Location						
		RM534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
Gizzard shad	May 1975	3.0	2.6	15.0	3.6	2.7	3.0	1.0
Goldeye		9.0	3.4	3.0	2.4	5.5	13.0	2.0
Carp		5.0	8.6	63.0	8.4	2.7	14.0	8.0
River carpsucker		8.0	16.3	9.0	26.4	17.7	22.0	16.0
Total CPE		28.0	40.6	108.0	60.0	30.0	66.0	31.0
Number of Species		6	13	7	13	5	11	8
Gizzard shad	June 1975	1.2	3.0	3.0	0	1.4	11.0	0
Goldeye		3.5	0	0	1.0	5.7	3.0	1.9
Carp		3.5	20.0	45.0	16.0	1.4	7.0	12.2
River Carpsucker		10.4	17.0	6.0	12.0	2.8	19.0	17.8
Total CPE		21	47.0	63.0	38.0	14.1	44.0	34.6
Number of Species		6	5	6	9	6	7	6
Gizzard shad	July 1975	9.0	3.6	6.0	19.5	13.1	20.0	8.6
Goldeye		0	0	0	3.0	1.9	4.4	4.3
Carp		9.0	7.2	21.0	9.0	9.4	13.3	5.4
River Carpsucker		3.0	1.2	57.0	0	3.8	10.0	4.3
Total CPE		24.0	15.6	105.0	40.5	35.8	51.0	30.2
Number of Species		4	6	7	9	8	7	7
Gizzard shad	August 1975	4.1	0	0	1.0	3.0	10.0	1.2
Goldeye		1.0	2.3	0	0	3.0	2.0	3.5
Carp		4.1	0	6.0	1.0	1.5	2.0	3.5
River Carpsucker		9.3	0	3.0	4.0	0	9.0	2.3
Total CPE		22.6	3.5	9.0	8.0	7.5	29.0	11.7
Number of Species		6	2	2	5	3	9	5
Gizzard shad	September 1975	4.8	0	55.0	24.0	16.5	15.0	10.7
Goldeye		0	0	2.5	1.5	3.0	2.0	1.1
Carp		1.2	8.4	15.0	1.5	7.5	2.0	1.1
River Carpsucker		9.6	6.0	5.0	6.0	10.5	7.0	8.6
Total CPE		20.4	24.0	87.5	34.5	45.0	34.0	32.3
Number of Species		6	5	6	5	7	8	6

Table 3-26. Total CPE and CPE of Selected Species by Location Collected from the Missouri River Near Cooper Nuclear Station 1975 to 1977 (Continued, Page 2 of 5)

Species	Date	Sampling Location RM534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
Gizzard shad	October 1975	3.2	2.0	80.0	2.5	6.0	19.0	0
Goldeye		1.1	5.0	0	2.5	0	0	0
Carp		1.1	1.0	15.0	1.3	0	1.0	0
River carpsucker		6.4	4.0	20.0	8.8	3.0	17.0	9.1
Total CPE		20.4	22.0	125.0	19.0	15.0	46.0	15.6
Number of Species		6	7	4	7	5	7	3
Gizzard shad	November 1975	1.5	1.5	219.0	1.2	1.5	1.0	1.0
Goldeye		1.5	1.5	6.0	1.2	0	1.0	1.0
Carp		1.5	7.5	3.0	2.4	9.0	5.0	4.0
River Carpsucker		3.0	3.0	15.0	10.8	15.0	21.0	6.0
Total CPE		12.0	22.5	255.0	21.6	31.5	39.0	[illegible]
Number of Species		5	6	7	8	4	8	5
Gizzard shad	May 1976	3.0	4.8	16.0	22.0	2.4	24.9	4.3
Goldeye		3.0	21.6	2.0	4.0	4.8	14.6	9.4
Carp		10.5	20.4	160.0	13.0	12.0	10.3	36.9
River Carpsucker		15.0	15.6	12.0	25.0	14.4	27.4	14.6
Total CPE		40.5	84.0	216.0	75.0	39.6	86.7	68.8
Number of Species		7	13	7	12	7	10	8
Gizzard shad	June 1976	9.6	13.0	0	7.2	1.2	13.2	0
Goldeye		9.6	1.0	0	1.2	2.4	8.4	5.0
Carp		12.0	9.0	27.0	28.8	3.6	20.4	15.0
River Carpsucker		18.0	27.0	12.0	4.8	14.4	7.2	8.0
Total CPE		58.8	56.0	57.0	58.8	22.8	54.0	30.0
Number of Species		11	10	7	12	5	7	4
Gizzard shad	July 1976	2.4	9.0	0	0	1.2	8.4	2.0
Goldeye		6.0	2.3	0	4.8	0	1.2	6.0
Carp		13.2	7.5	9.0	18.0	6.0	14.4	16.0
River Carpsucker		31.2	14.3	18.0	3.6	3.6	8.4	20.0
Total CPE		66.0	41.7	30.0	33.6	14.4	33.6	51.0
Number of Species		9	13	3	9	6	5	10

Table 3-26. Total CPE and CPE of Selected Species by Location collected from the Missouri River Near Cooper Nuclear Station 1975 to 1977 (Continued, Page 3 of 5)

		Sampling Location						
Species	Date	R534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
Gizzard shad	August 1976	43.0	78.8	0	8.4	9.6	29.0	11.1
Goldeye		0	1.5	0	2.4	3.6	4.0	4.3
Carp		3.0	4.5	12.0	7.2	6.0	9.0	6.0
River carpsucker		8.0	21.8	15.0	22.8	20.4	5.0	5.1
Total CPE		62.0	111.4	48.0	50.4	42.0	54.0	29.1
Number of Species		8	10	7	11	6	8	5
Gizzard shad	September 1976	10.0	11.0	48.0	46.5	5.0	21.0	7.0
Goldeye		5.0	4.0	0	3.0	3.0	1.0	3.0
Carp		3.0	13.0	33.0	7.5	3.0	1.0	7.0
River Carpsucker		5.0	10.0	24.0	9.0	9.0	6.0	5.0
Total CPE		26.0	45.0	144.0	76.5	22.0	34.0	25.0
Number of Species		6	9	8	10	5	9	7
Gizzard shad	October 1976	0	1.0	0	2.4	0	1.5	0
Goldeye		10.0	3.0	9.0	3.6	7.2	3.0	3.0
Carp		24.0	14.0	3.0	14.4	1.2	15.8	3.0
River Carpsucker		4.0	14.0	9.0	24.0	2.4	16.5	1.0
Total CPE		44.0	48.0	27.0	58.8	10.8	51.4	8.0
Number of Species		4	9	4	9	3	11	4
Gizzard shad	November 1976	*	3.0	90.0	6.0	1.2	6.0	0
Goldeye			37.0	0	9.0	3.6	0	11.0
Carp			18.0	3.0	19.5	16.8	5.0	6.0
River Carpsucker			9.0	18.0	24.0	7.2	3.0	0
Total CPE			72.0	123.0	61.5	56.4	18.0	17.0
Number of Species			8	6	6	7	5	2
Gizzard shad	May 1977	6.0	30.0	18.0	48.0	34.0	33.0	4.0
Goldeye		8.0	7.0	3.0	6.0	8.0	3.0	7.0
Carp		1.0	6.0	12.0	3.0	3.0	6.0	4.0
River Carpsucker		16.0	22.0	3.0	7.5	7.0	5.0	1.0
Total CPE		35.0	80.0	48.0	72.0	58.0	55.0	19.0
Number of Species		8	12	7	8	9	10	7

Table 3-26. Total CPE and CPE of Selected Species by Location Collected from the Missouri River Near Cooper Nuclear Station 1975 to 1977 (Continued, Page 4 of 5)

Species	Date	Sampling Location						
		R534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
Gizzard shad	June 1977	2.0	9.0	0.0	1.5	9.0	1.0	1.0
Goldeye		3.0	10.0	0.0	1.5	4.0	3.0	8.0
Carp		5.0	5.0	0.0	3.0	5.0	0.0	3.0
River carpsucker		8.0	14.0	0.0	18.0	9.0	2.0	1.0
Total CPE		25.0	42.0	9.0	30.0	31.0	10.0	14.0
Number of Species		9	5	3	8	8	7	5
Gizzard shad	July 1977	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Goldeye		1.0	1.0	0.0	1.5	3.0	2.0	4.0
Carp		11.0	5.0	9.0	3.0	2.0	6.0	6.0
River Carpsucker		9.0	20.0	0.0	30.0	12.0	9.0	1.0
Total CPE		21.0	31.0	24.0	43.0	20.0	21.0	13.0
Number of Species		3	5	3	9	5	6	5
Gizzard shad	August 1977	6.0	13.0	0.0	1.5	9.0	14.0	0.0
Goldeye		8.0	2.0	0.0	4.5	3.0	0.0	3.0
Carp		2.0	5.0	27.0	10.5	1.0	15.0	7.0
River Carpsucker		9.0	24.0	0.0	3.0	14.0	19.0	0.0
Total CPE		37.0	54.0	60.0	24.0	33.0	59.0	17.0
Number of Species		12	9	6	6	7	10	4
Gizzard shad	September 1977	2.0	14.0	0.0	13.5	4.0	5.0	0.0
Goldeye		3.0	10.0	0.0	7.5	1.0	2.0	3.0
Carp		4.0	7.0	24.0	7.5	2.0	2.0	6.0
River Carpsucker		18.0	33.0	3.0	24.0	11.0	42.0	3.0
Total CPE		35.0	76.0	63.0	69.0	23.0	61.0	19.0
Number of Species		8	9	6	9	7	11	7
Gizzard shad	October 1977	0.0	10.0	6.0	9.0	11.0	19.0	0.0
Goldeye		5.0	5.0	3.0	3.0	13.0	4.0	3.0
Carp		11.0	12.0	24.0	12.0	13.0	10.0	11.0
River Carpsucker		1.0	30.0	15.0	15.0	14.0	9.0	3.0
Total CPE		25.0	68.0	81.0	52.5	61.0	52.0	21.0
Number of Species		6	11	8	9	8	8	5

Table 3-26. Total CPE and CPE of Selected Species by Location Collected from the Missouri River Near Cooper Nuclear Station 1975 to 1977 (Continued, Page 5 of 5)

Species	Date	Sampling Location						
		RM534N	RM534M	Discharge	RM532N	RM532M	RM530N	RM530M
Gizzard shad	November 1977	0.0	0.0	9.0	0.0	1.0	0.0	0.0
Goldeye		10.0	11.0	3.0	4.5	9.0	4.0	4.0
Carp		8.0	2.0	24.0	4.5	13.0	6.0	2.0
River carpsucker		1.0	8.0	9.0	1.5	9.0	6.0	1.0
Total CPE		24.0	23.0	81.0	16.5	40.0	19.0	7.0
Number of Species		4	5	8	5	6	6	7

RM River Mile

Source: ESE Compiled from Reference Documents 9, 10, 11, 12, 13.

other factor (perhaps attraction to the canal structure with associated periphyton and epifauna) was functioning to account for this high CPE. Results of other sampling periods during the spring and fall do suggest thermal attraction.

Cooper Nuclear Station does not interrupt fish movement in the Missouri River, and the plume does not form a barrier.[39] Tagging studies conducted near Cooper and Fort Calhoun Nuclear Stations indicated random movement with no apparent trends.[39] Other studies have also indicated that fish will move in and out of thermal plumes.

Potential alteration in fish feeding habits as a result of Cooper Nuclear Station operation was evaluated. Data on the feeding habits of several species indicated that the station had no significant impact on feeding habits and were typical for the same species found elsewhere.[40,41,42]

In temperate regions, sudden decreases in water temperature or cold shock may be of greater importance than heated discharge, particularly during cold winter months. As noted previously (see Section 3.1.1.2) river sampling for fish was ended each year with November collections. Because of the lack of winter sampling, this potential problem could not be addressed in detail. However, inspection of the data for October and November indicated that in most years gizzard shad, carp, and to a lesser extent, goldeye, were the most abundant species in the discharge area, and therefore were most likely to experience cold shock.

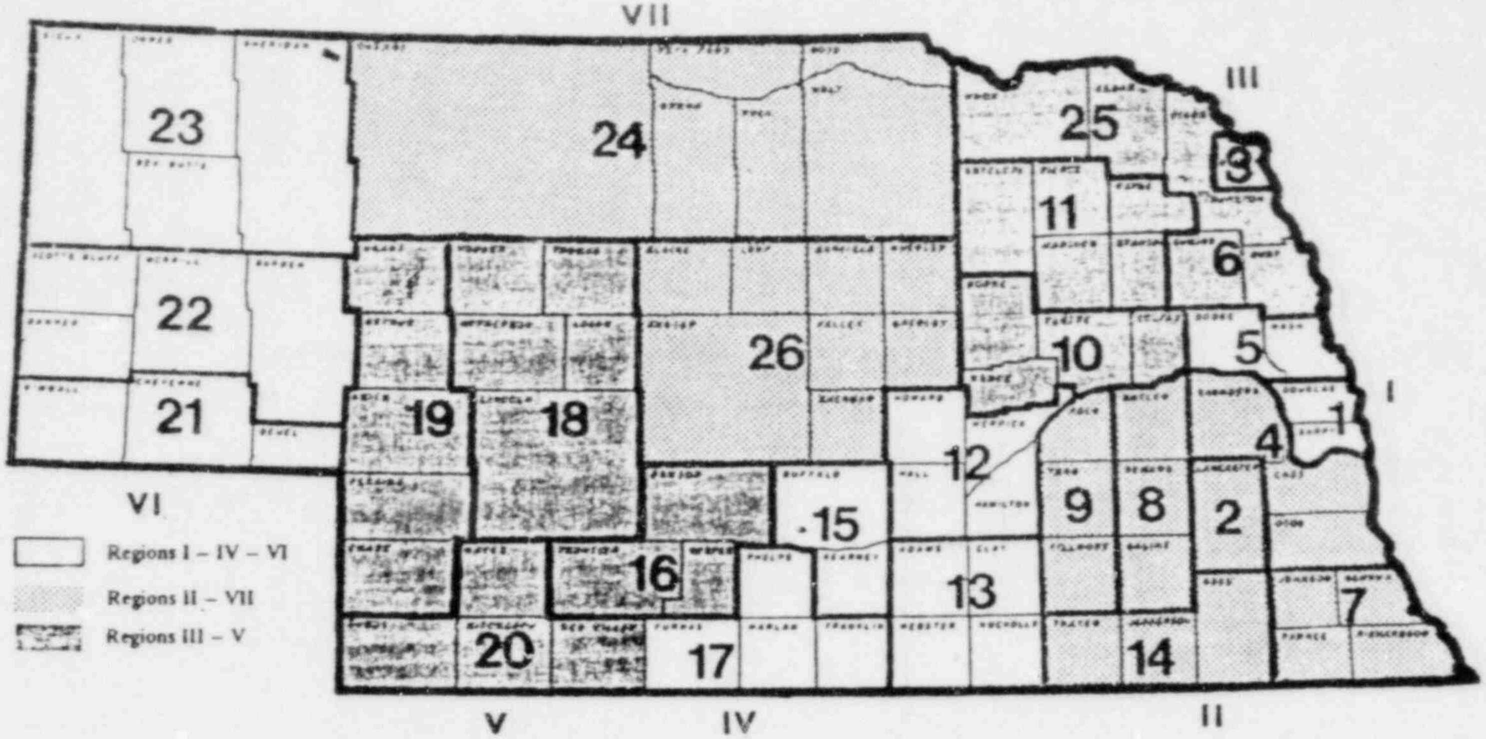
3.4.1.5 Commercial and Recreational Fisheries--One of several important considerations in evaluating potential impacts of the Cooper Nuclear Station discharge to the Missouri River is the availability and suitability of the area to recreational and commercial fisheries. Therefore, any impairment to the use of available water resources by fishermen would result in recreational and economic impacts. At this time the channelized Missouri River seems to be utilized by small numbers of fishermen. However, the 1979 State Comprehensive Outdoor Recreation

Plan (SCORP) predicts increased usage for this region.[43] The state recreational planning regions are depicted in Figure 3-14. Cooper Nuclear Station is located in Region II as is Indian Cave State Park. This park, located 35 miles south-southeast of Cooper Nuclear Station, is currently under development and is expected to become a major recreational facility. This development may well increase river usage near Cooper Nuclear Station.

Thermal discharges have become popular and favorite winter fishing locations at a variety of power plants located on lakes and rivers in the continental United States.[20,37] Where sports fisheries existed at these discharges, they generally provided desirable species such as trout, bass, and pike. Merriman and Thorpe[20] reported that sports fisheries were developed in the discharge of the Connecticut Yankee Power Plant in the winter to spring season. These fisheries were considered the most successful fisheries, and fishermen using the discharge during cold months caught twice as many fish per unit effort as those who fished on the river in the April to November period. It should be noted, however, that these fisheries have the potential of being depleted or the balance of prey to predator in the fish community could be altered.

As with other stations, Cooper Nuclear Station should have the potential for providing some sort of winter sports fisheries in the outfall region. Although, game and commercial fish species of this section of the Missouri River are limited, the station has the potential for winter catfish fisheries, particularly channel catfish. This potential has not materialized because the area is not accessible to anglers from the shoreline, and boating usually is impaired during the winter time.

In 1968, the Missouri River was divided into three separate sections (fisheries recordkeeping), the unchannelized section, Section I includes the part of the river between Yanktown and Sioux City (see Figure 3-15). Section II is the channelized section of the river between Sioux City



SOURCE: STATE COMPREHENSIVE OUTDOOR RECREATION PLAN, NEBRASKA GAME AND PARKS COMMISSION, 1979.

Figure 3-14
NEBRASKA RECREATIONAL PLANNING REGIONS

COOPER NUCLEAR STATION

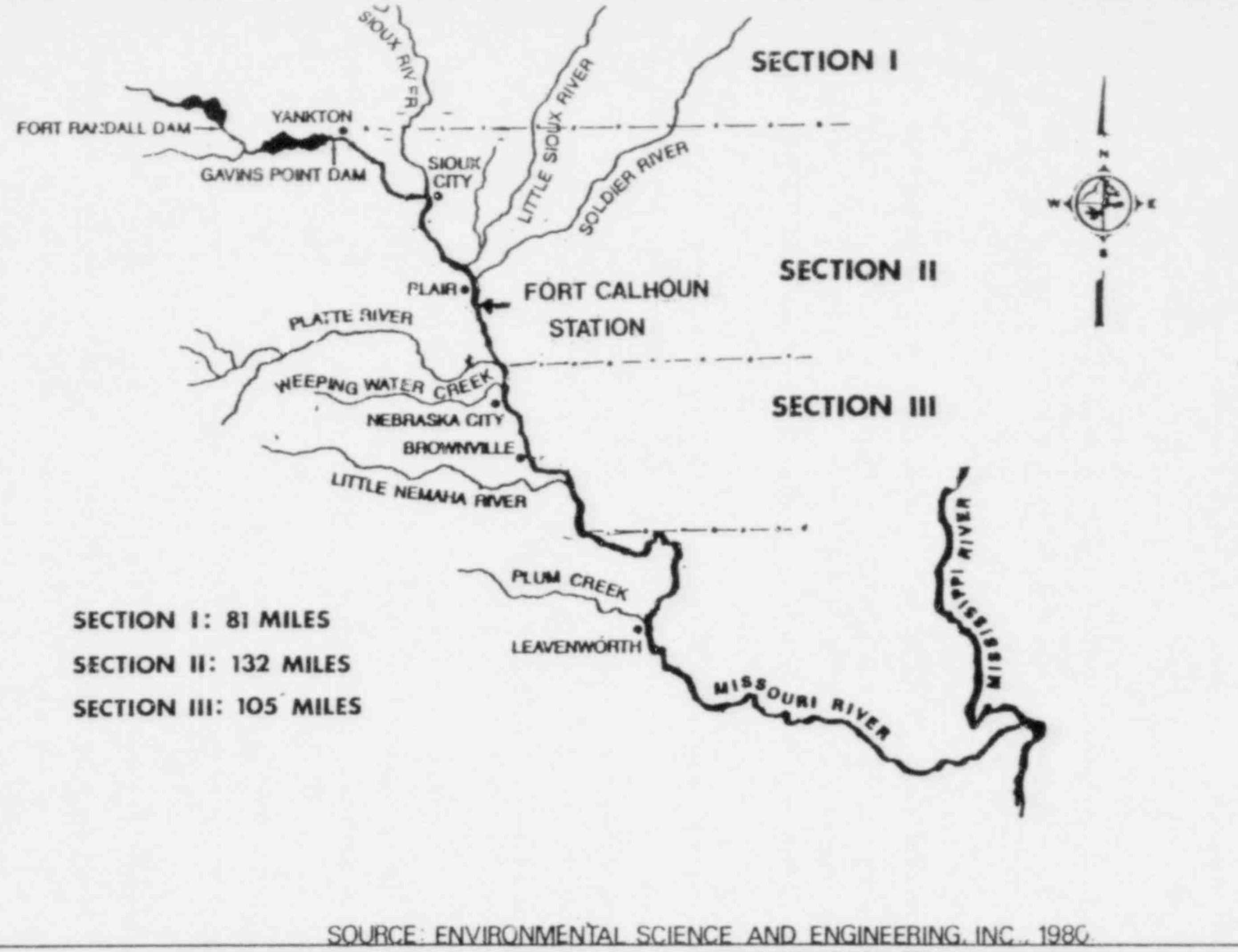


Figure 3-15
SECTIONS OF THE CHANNELIZED AND UNCHANNELIZED MISSOURI RIVER

COOPER NUCLEAR STATION

and the mouth of the Platte River. Section III is the channelized section of the Missouri River between the Platte River and Kansas City. Section III includes Cooper Nuclear Station and thus, the station's impact on the river's fishery, if any, is most likely to be reflected in the fisheries of that section.

Statistics on commercial fishery landing from the Missouri River were available from Nebraska Game and Parks Commission[44] covering the period 1972 and 1974 to 1976.

The most recent commercial data on these three sections were reported in 1976 and summarized in Table 3-27. A comparison of catch per unit of effort for the Missouri River in the 1972, 1974, 1975, and 1976 period is given in Table 3-28. An investigation of data of Table 3-29 indicates:

1. The unchannelized section of the Missouri River yields greater catch/unit of effort (numbers and biomass) than the channelized sections, and
2. Catch per effort from Section III is intermediate between Section I and Section II.

Schainost[44] expressed concern that the decline in the general fisheries of the Missouri River could signify a decline in the fish population of the river. However, there could be a change in the type of fisherman currently utilizing the river, i.e., from commercial fishermen to hobbyist. Data summarized in Table 3-28 indicates a general decline in the average size of individual fish. For example, when total numbers and total weights (all species) are compared it was calculated that the average weight has declined from 9.4 lbs in 1974 to 7.0 lbs in 1976. This decrease in size may be attributed to a host of variables, therefore establishing any causal relationship is not possible because of lack of system-wide data.

Table 3-27. Commercial Fish Landing and Catch Per Unit of Effort in the Missouri River Segments in 1976*

Section	Channel Catfish Number	Channel Catfish Weight (lb)	Carp Number	Carp Weight (lb)	Flathead Catfish Number	Flathead Catfish Weight (lb)	Buffalo Number	Buffalo Weight (lb)	Others Number	Others Weight (lb)	Total Number	Total Weight (lb)	Catch/Effort† Number	Catch/Effort† Weight (lb)	Catch Per River Mile Number	Catch Per River Mile Weight (lb)	Catch Per Fisherman Number	Catch Per Fisherman Weight (lb)
I	597	1,467	2,661	8,118	26	242	2,690	11,731	581	1,110	6,555	22,668	18.6	64.4	80.9	280	163.9	567
II	2,817	6,056	7,552	27,671	548	3,520	4,042	17,086	1,303	3,064	16,262	57,397	6.1	21.4	117.8	416	141.4	499
III	2,382	4,996	8,153	23,463	500	2,816	408	2,146	325	445	11,768	33,866	8.4	24.1	112.1	322	226.3	651

River Mile Sampled		Pieces of Gear Used	Number of Permits** (reported catch)
I	81 mile	352	40
II	138	2670	115
III	105	1407	52

* Catch per effort is defined as number or weight per gear.
† Encompasses Cooper Nuclear Station, Unit 1.
** Each permit represents a fisherman.

Source: Schainost, S., 1976, Reference No. 42.

Table 3-28. Commercial Fish Landing and Catch Per Unit of Effort, Missouri River, 1972 Through 1976

Year	Channel Catfish		Carp		Flathead Catfish		Buffalo		Others		Total		Catch/Effort*		Catch Per River Mile	Catch Per Fisherman
	Number	Weight (lb)	Number	Weight (lb)	Number	Weight (lb)	Number	Weight (lb)	Number	Weight (lb)	Number	Weight (lb)	Number	Weight (lb)	Pounds (lb)	Pounds (lb)
1972	N/A	13,009	N/A	69,339	N/A	6,568	N/A	37,833	N/A	5,399	N/A	142,148	N/A	37.6	439	883
1974	4,417	12,371	4,748	53,411	553	5,435	1,084	31,762	597	5,190	11,399	108,169	3.8	24.7	334	615
1975	3,661	15,935	7,768	63,587	448	7,413	3,528	36,615	1,067	7,067	16,509	130,617	6.8	32.2	403	726
1976	2,817	12,519	7,552	59,252	548	6,578	4,042	30,963	1,303	4,619	16,262	113,931	6.1	25.7	352	550

* Catch per effort is defined as pounds or numbers per piece of gear.

N/A = Not Available.

Source: Schainoist, S., 1976, Reference No. 42.

3.4.1.6 Summary and Conclusions: Thermal Effect--No significant adverse impacts to the biota of the Missouri River from Cooper Nuclear Station discharge were detected. Localized effects in the vicinity of the discharge have been observed. This includes changes in the diversity and productivity of phytoplankton, periphyton, and benthic invertebrates at a certain time of the year. The plant neither enhances the fisheries of the Missouri River nor does it provide good winter fisheries such as those reported elsewhere. Cooper Nuclear Station does not interrupt fish movement in the river.

There has been a general decline in the Missouri River commercial fisheries, however, the heated discharges from the station could not be directly implicated. The decline is thought to be primarily related to man's activities (e.g., channelization), although part may be related to the use of Missouri River as a cooling water source for several plants located on the river.

3.4.2 Entrainment of Fish Larvae

Ichthyoplankton entrainment by Cooper Nuclear Station was evaluated during the operational period from 1974 to 1978. In addition, a short-term study was conducted in June and July 1973 to assess the effects of condenser passage without thermal loading. Sampling locations varied during the study but always included comparisons between the Nebraska and Missouri sides of the river (see Table 3-29). Samples were generally collected at the surface or within one meter of the surface. Larvae were sampled at varying intervals from May through July annually.

Previous entrainment estimates were based upon the percentage of the river diverted through the station, larval densities and some unspecified factor related to channel configuration.[12,13]

Table 3-29. Ichthyoplankton Sampling Location Summary

Sampling Year	Location Intake (1)	4*	2†	Discharge
1974	+		+	
1975	+		+	+
1976	+		+	+
1977	+	+	+	
1978	+	+	+	

* Location 4 was a mid-channel location perpendicular to the intake.
† Location 2 was near the Missouri shoreline perpendicular to the intake.

Source: ESE, Compiled from Reference Document Numbers 9 through 13.

Several factors influence entrainment estimates and require the following assumptions to be made for this analysis.

1. Intake velocities, although not measured, were always high enough to entrain larvae from the area of the intake; therefore, collections from the intake were representative of entrainment;
2. The entire water column is uniformly drawn in by Cooper Nuclear Station, therefore, larvae in any portion of the water column are subject to entrainment; and
3. The diel rate of larval drift is not significantly different and sampling events are representative.

Entrainment estimates made in this study were based upon reported larval densities and station water usage. An alternate estimate is provided by fitting a Gaussian curve through larval density distribution data and estimating the area under the curve which was assumed to represent average larval densities in the May to July period. The fitting procedure was similiar to that described by Gauch and Chase.[45] There are no implications within the estimate concerning actual population distribution (i.e., the model does not imply that the population has a random distribution in nature). The estimate indicates that:

1. Given a set of apparent abundance data, a curve can be generated that may statistically indicate the abundance trend between and within collection points;
2. A point in time (at ±95 percent confidence intervals) when peak abundance may have occurred; and
3. An integrated value for an estimated total population abundance.

Five years of ichthyoplankton studies in the vicinity of Cooper Nuclear Station indicated the occurrence of 10 to 15 taxa of larval fish. These larval were generally present in the vicinity of the station from early May through July (see Figure 3-16). However, larvae appeared in the drift as early as April and as late as August.[46] Fish larvae were generally abundant in the June through July period with low densities being reported before and after these maxima. This pattern is a function of several factors, with water temperature being the most important.

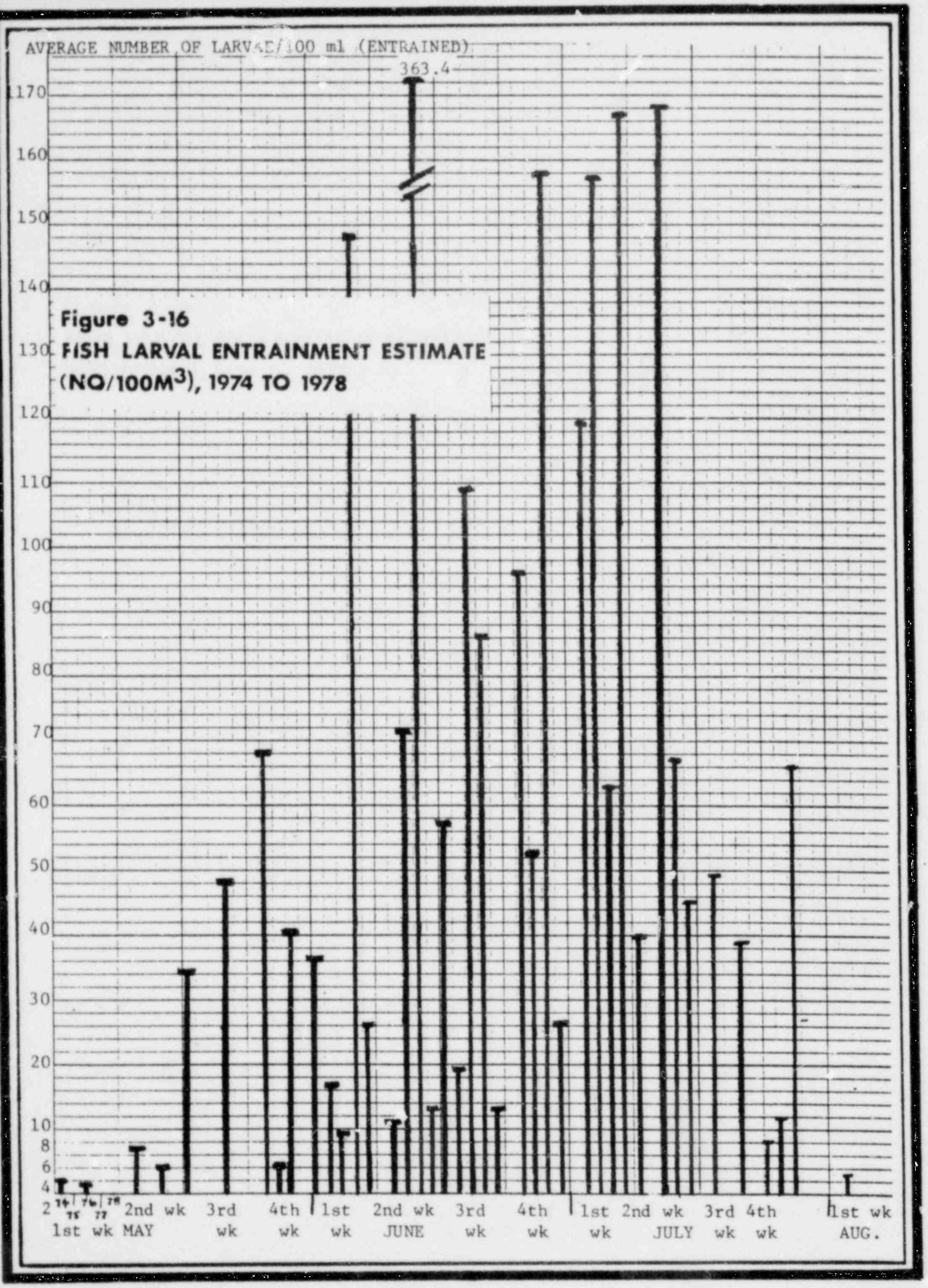


Figure 3-16
FISH LARVAL ENTRAINMENT ESTIMATE ($NO/100M^3$), 1974 TO 1978

The taxa most encountered in the entrainment studies, in order of abundance, were freshwater drum, suckers, minnows, carp, and gizzard shad (see Table 3-30). It is worth noting that adult carp and goldeye were dominant in river fish collections, but these two species composed a small portion of the entrained larvae. This suggests a sampling bias, selectivity and/or differences in larval distribution due either to the hydrodynamics of the Missouri River or larval fish behavior.

Hydrodynamic forces apparently affect larval distribution in the Missouri River. Cross-river distribution data were tabulated (see Table 3-30). Examination of the data for 1974 through 1976 indicated that Location Number 1 (intake) frequently had significantly greater densities than Location Number 2 (see Table 3-31). In 1977 a mid-channel collection (Location 4) was added to the sampling program. When examined graphically (see Figure 3-17) it can be seen that the apparent distribution trends revealed by just two stations were misleading. Although densities at Location 1 still accounted for a large percentage of the total ichthyoplankton, many more larvae pass the station in the mid-channel and Missouri regions of the river than would have been predicted from the early data. Thus, early entrainment estimates may have been too high.

It was believed that the ichthyoplankton collected near Cooper Nuclear Station was derived in part from the Lewis and Clark Reservoir, spawning in the unchannelized upper river and tributary stream contributions. Harrow and Schlesinger[46] for example, noted that the larval contributions from the Platte River were of sufficient dimension to alter the composition of the Missouri River larval drift from the point of input to the confluence with the Mississippi River.

Entrainment estimates have ranged from less than 1 to 12.9 percent of the river drift.[12,13] Density estimates, per se, for entrainment have only been reported by Cada.[47] Entrainment losses were calculated according to the assumptions stated previously.

Table 3-30. Summary of Mean Fish Larvae Densities in the Missouri River Near the Intake Structure of Cooper Nuclear Station, 1973 to 1978

Taxa	1973		1974		1975		1976		1977		1978	
	No./100m^3	Percent	No./100m^3	Percent	No./100m^3	Percent	No./100m^3	Percent	No./100m^3	Percent	No./100m^3	Percent
Scaphirhynchus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Gizzard shad	2.3	5.1	0.6	1.6	0.1	0.2	1.0	1.0	2.5	1.5	<0.1	0.1
Goldeye	0.0	0.0	0.0	0.0	0.5	1.1	0.6	0.6	0.1	0.1	0.3	0.9
Carp	1.2	2.8	1.3	3.8	3.1	6.6	0.4	0.4	1.9	1.1	2.0	6.9
Cyprinidae	6.4	14.4	4.6	13.3	5.1	10.6	4.8	4.6	6.4	3.6	0.8	2.9
Catostomidae	0.3	0.7	15.3	44.8	17.1	35.7	18.2	17.6	34.0	19.5	3.1	10.9
Cyprinidae-Catostomidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	9.3
Ictaluridae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	<0.1	0.1
Brook stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	<0.1
Morone sp.	0.2	0.5	0.3	0.8	0.3	0.6	0.2	0.2	0.8	0.4	0.0	0.0
Lepomis sp.	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centrachidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	<0.1
Percidae	0.1	0.2	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	<0.1	<0.1
Stizostedion sp.	0.7	1.6	0.6	1.7	1.1	2.4	0.0	0.0	0.3	0.2	<0.1	<0.1
Freshwater drum	31.2	70.2	11.1	32.6	13.9	29.0	78.0	75.5	126.9	72.7	16.8	59.5
Unidentified	1.8	4.2	0.4	1.3	6.4	13.5	0.0	0.0	1.0	0.6	2.5	9.0
TOTAL	44.3		34.2		47.8		143.2		174.6		28.3	

Source: Reference Document Number 13.

Table 3-31. Cross-River Distribution of Total Densities of Fish Larvae (Number/100m^3) in the Missouri River near Cooper Nuclear Station

Sampling Period	Location			Significant (PSO x .05)
	Intake (i)	4*	2†	
May 8, 1974	0.032	---	0.008	NS
May 23, 1974	0.424	---	0.524	NS
June 4, 1974	0.365	---	0.351	NS
June 17, 1974	0.553	---	0.594	NS
July 10, 1974	0.565	---	0.232	1>2
July 25, 1974	0.111	---	0.057	NS
May 13, 1975	12.41	---	1.29	1>2
May 27, 1975	77.36	---	58.32	NS
June 5, 1975	25.58	---	8.11	1>2
June 13, 1975	19.06	---	3.90	1>2
June 18, 1975	25.06	---	11.40	1>2
June 27, 1975	108.67	---	82.95	NS
July 1, 1975	111.64	---	125.63	NS
July 15, 1975	69.46	---	29.04	1>2
July 31, 1975	15.66	---	9.00	NS
August 1, 1975	3.88	---	1.87	NS
May 5, 1976	0.1	---	0	NS
May 24, 1976	5.0	---	3.1	NS
June 4, 1976	9.3	---	8.2	NS
June 10, 1976	100.2	---	42.7	1>2
June 18, 1976	179.0	---	38.1	1>2
June 25, 1976	89.2	---	17.7	1>2
July 1, 1976	280.1	---	34.5	1>2
July 9, 1976	243.6	---	92.6	1>2
July 23, 1976	23.1	---	108.9	2>1
May 11, 1977	6.0	3.5	2.8	NS
May 23, 1977	59.8	39.0	44.1	1>2, 4
May 31, 1977	58.0	29.4	33.6	NS
June 7, 1977	262.3	95.8	86.9	NS
June 16, 1977	662.4	131.2	296.8	1>2, 4
June 22, 1977	165.2	32.2	61.4	1>2, 4
June 28, 1977	313.4	59.9	101.6	NS
July 8, 1977	65.3	77.7	47.1	NS
July 14, 1977	75.5	39.5	84.5	NS
July 20, 1977	77.7	17.9	20.6	1>2, 4

Table 3-31. Cross-River Distribution of Total Densities of Fish Larvae ($Number/100m^3$) in the Missouri River near Cooper Nuclear Station (Continued, Page 2 of 2)

Sampling Period	Location: Intake (1)	4*	2†	Significant (PSO x .05)
June 1, 1978	37.6	9.3	26.3	1>2>4
June 8, 1978	17.5	29.2	34.2	2>1>4
June 15, 1978	12.0	14.7	13.0	NS
June 22, 1978	19.2	5.2	14.5	NS
June 29, 1978	42.5	11.7	22.4	1>2, 4
July 6, 1978	147.0	135.4	218.3	2>1, 4
July 13, 1978	102.1	8.4	25.5	1>2, 4

Summary of Significance by Station

NS	50%
1>	43%
2>	7%

* Location 4 was a mid-channel location perpendicular to the intake.
† Location 2 was near the Missouri shoreline perpendicular to the intake.

Source: ESE, Compiled from Reference Document Numbers 9 through 13.

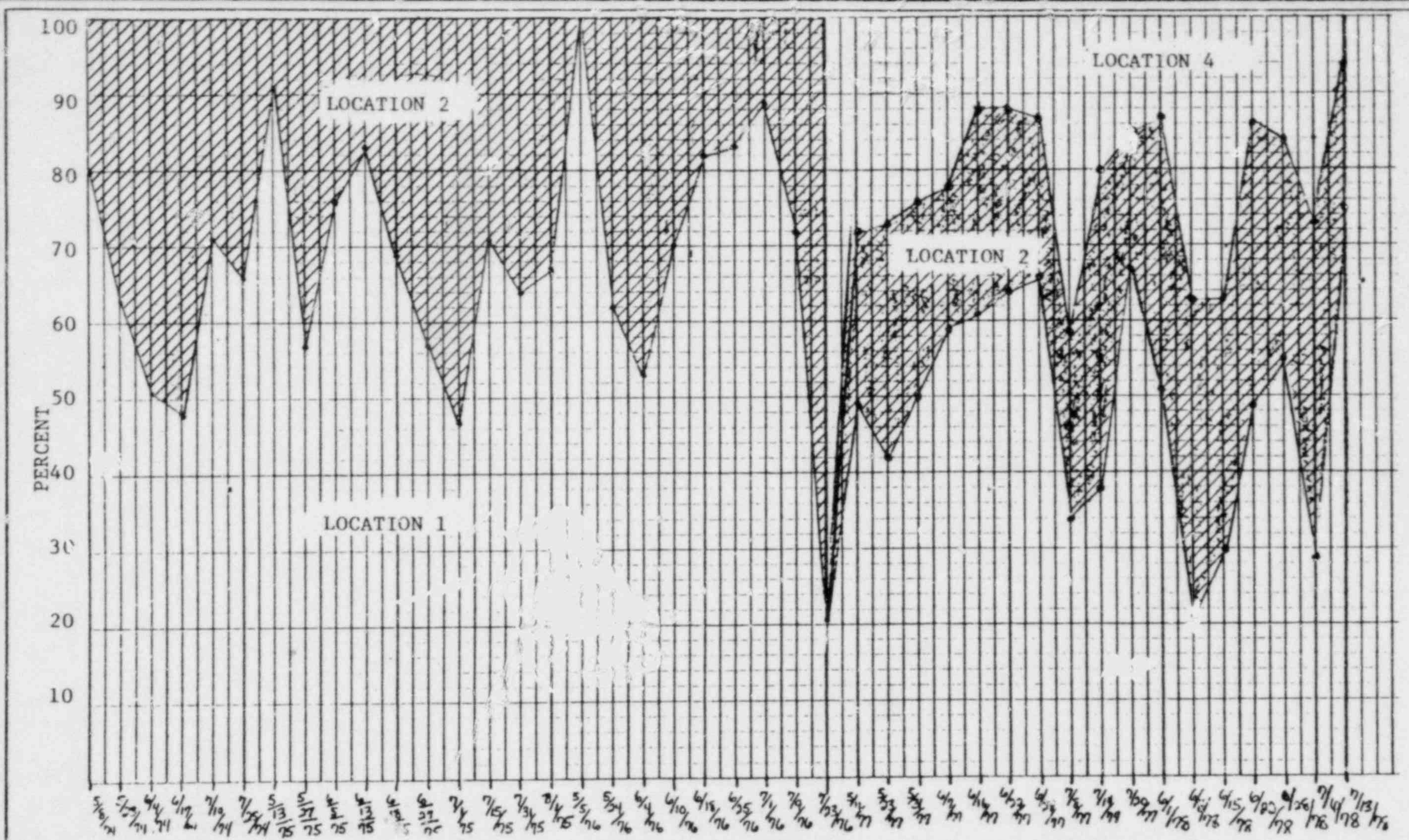


Figure 3-17
ICHTHYOPLANKTON DISTRIBUTION BY LOCATION IN THE MISSOURI RIVER NEAR COOPER NUCLEAR STATION, 1974 TO 1978

COOPER NUCLEAR STATION

A frequently encountered problem of ichthyoplankton survivability studies results from sampling-induced mortality. At Cooper Nuclear Station, survivability studies were conducted for several years. After repeated sampling, mortality rates were frequently higher at the intake location than at the discharge location. In 1977, mortality studies were discontinued and entrainment losses were estimated from cross-river distributional studies. In addition, individuals entrained were considered "lost" to the river system. This assumption was made because survivability studies were of short duration and data on long-term, latent effects were lacking. These assumptions and subsequent estimates have limitations. For example, the portion of the water column which is withdrawn by Cooper Nuclear Station at varying river stages is unknown. Since the majority of larval fish occur in the upper meter of the water column, this lack of information could bias the estimates. Another problem involves the horizontal or lateral area of entrainment effect relative to the intake. These are just two examples of the multitude of problems encountered when estimating entrainment losses.

Entrainment estimates for total fish larval are provided in Table 3-32. Data contained in this table are presented in sequence for ease of computation of entrainment estimates. These estimates (see Table 3-32) provide total ichthyoplankton entrainment by sampling date. These estimates indicated that daily larval losses ranged from 86,400 larvae per day to over 17 million larvae per day (see Table 3-31). In turn, these estimates were further extrapolated by major taxa and annual estimates of adults lost to the system were made (see Table 3-33). Estimation of adult loss was based on the method of Horst[48] which is simply to convert the number of fish larvae lost to entrainment to the number of adults that would have been recruited. The annual estimates were based on a conservative estimate of 77 days to represent the period of larval drift (mid-May through July).

In summary, loss of adults to the system was predicated on the assumption of 0.1 percent survival to adulthood. Theoretical, density-dependent and density-independent variables were not considered in this analysis. As an additional estimate data from Reference Document

Table 3-32. Estimated Larval Entrainment by Cooper Nuclear Station, 1974 through 1978

Sampling Date	Instantaneous Intake Flow ($feet^3$)	Daily Intake Flow ($feet^3$)	Daily Intake Flow (m^3)	Larval Densities Near Intake ($Number/m^3$)	Estimated Number of Larvae Entrained
May 08, 1974	1,087.5	9.4×10^7	2.7×10^6	.032	86,400
May 23, 1974	725	6.3×10^7	1.8×10^6	.424	763,200
June 04, 1974	0	0	0	.365	0
June 17, 1974	725	6.3×10^7	1.8×10^6	.553	995,400
July 10, 1974	725	6.3×10^7	1.8×10^6	.565	1,017,000
July 25, 1974	0	0	0	.111	0
May 13, 1975	725	6.3×10^7	1.8×10^6	.124	223,200
May 27, 1975	725	6.3×10^7	1.8×10^6	.774	1,393,200
June 05, 1975	1,087.5	9.4×10^7	2.7×10^6	.256	691,200
June 13, 1975	725	6.3×10^7	1.8×10^6	.191	343,800
June 18, 1975	725	6.3×10^7	1.8×10^6	.256	460,800
June 27, 1975	725	6.3×10^7	1.8×10^6	1.087	1,956,600
July 01, 1975	1,087.5	9.4×10^7	2.7×10^6	1.116	3,013,200
July 15, 1975	1,087.5	9.4×10^7	2.7×10^6	.695	1,876,500
July 31, 1975	1,450	1.3×10^8	3.7×10^6	.157	580,900
August 01, 1975	1,450	1.3×10^8	3.7×10^6	.039	144,300
May 05, 1976	1,087.5	9.4×10^7	2.7×10^6	.005	13,500
May 24, 1976	725	6.3×10^7	1.8×10^6	.050	90,000
June 04, 1976	1,087.5	9.4×10^7	2.7×10^6	.093	251,100
June 10, 1976	1,087.5	9.4×10^7	2.7×10^6	1.002	2,705,400
June 18, 1976	1,087.5	9.4×10^7	2.7×10^6	1.790	4,833,000
June 25, 1976	725	6.3×10^7	1.8×10^6	.892	1,605,600
July 01, 1976	1,087.5	9.4×10^7	2.7×10^6	2.801	7,562,700
July 09, 1976	1,087.5	9.4×10^7	2.7×10^6	2.436	6,577,200
July 23, 1976	1,087.5	9.4×10^7	2.7×10^6	.231	623,700

Table 3-32. Estimated Larval Entrainment by Cooper Nuclear Station, 1974 through 1978 (Continued, Page 2 of 2)

Sampling Date	Instantaneous Intake Flow ($feet^3$)	Daily Intake Flow ($feet^3$)	Daily Intake Flow (m^3)	Larval Densities Near Intake ($Number/m^3$)	Estimated Number of Larvae Entrained
May 11, 1977	1,087.5	9.4×10^7	2.7×10^6	.060	162,000
May 23, 1977	1,087.5	9.4×10^7	2.7×10^6	.598	1,614,600
May 31, 1977	1,087.5	9.4×10^7	2.7×10^6	.580	1,566,000
June 07, 1977	1,087.5	9.4×10^7	2.7×10^6	2.623	7,082,100
June 16, 1977	1,087.5	9.4×10^7	2.7×10^6	6.624	17,884,800
June 22, 1977	1,087.5	9.4×10^7	2.7×10^6	1.652	4,460,400
June 28, 1977	1,450	1.3×10^8	3.7×10^6	3.134	11,595,800
July 08, 1977	1,450	1.3×10^8	3.7×10^6	.653	2,416,100
July 14, 1977	1,087.5	9.4×10^7	2.7×10^6	.755	2,038,500
July 20, 1977	1,450	1.3×10^8	3.7×10^6	.777	2,874,900
June 01, 1978	362.5	3.1×10^7	8.8×10^5	.376	330,880
June 08, 1978	1,450	1.3×10^8	3.7×10^6	.175	647,500
June 15, 1978	1,450	1.3×10^8	3.7×10^6	.120	444,000
June 22, 1978	1.450	1.3×10^8	3.7×10^6	.192	710,400
June 28, 1978	1,450	1.3×10^8	3.7×10^6	.425	1,572,500
July 06, 1978	1,087.5	9.4×10^7	2.7×10^6	1.470	3,969,000
July 13, 1978	1,450	1.3×10^8	3.7×10^6	1.021	3,777,700

Source: ESE, 1981.

Table 3-33. Calculated Annual Estimates of Entrained Larvae by Taxon, 1974 to 1978

Taxa	1974		1975		1976		1977		1978	
	Number Larvae Entrained	Loss to Adult Fisheries	Number Larvae Entrained	Loss to Adult Fisheries	Number of Larvae Entrained	Loss to Adult Fisheries	Number of Larvae Entrained	Loss to Adult Fisheries	Number of Larvae Entrained	Loss to Adult Fisheries
Scaphirhynchus sp.	0	0	0	0	0	0	0	0	251,943	251
Gizzard shad	881,496	881	164,529	164	2,075,766	2,075	201,812,891	201,812	125,972	125
Goldeye	0	0	904,909	904	1,162,429	1,162	1,592,212	1,592	1,133,745	1,133
Carp	2,093,553	2,093	5,429,456	5,429	830,306	830	2,149,486	2,149	8,692,052	8,692
Cyprinidae	7,327,435	7,327	8,720,036	8,720	9,548,524	9,548	7,125,149	7,125	3,653,181	3,653
Catostomidae	24,681,888	24,681	29,368,423	29,368	36,533,482	36,533	38,770,366	38,770	13,730,922	13,730
Cyprinidae-Catostomidae	0	0	0	0	0	0	0	0	11,715,374	11,715
Ictaluridae	0	0	0	0	0	0	792,125	792	125,971	125
Morone sp.	4,407,480	440	493,586	493	415,153	415	792,125	792	*	*
Percidae	0	0	238,567	238	0	0			*	*
Stizostedion sp.	936,589	936	1,974,348	1,974	0	0	394,072	394	*	*
Freshwater drum	17,960,481	17,960	23,856,702	23,856	156,927,910	156,927	144,612,669	144,612	75,079,174	75,079
Unidentified	716,215	716	11,105,706	11,105	0	0	1,190,178	1,190	11,337,459	11,337

* Total Densities <0.1.

Source: ESE, 1981.

Number 12 and Cada's dissertation[47] were combined and fit to a Gaussian curve (see Figure 3-18). These data sets were selected for detailed analysis because the sampling methods were comparable, i.e., replicate number, net diminsion; mesh size and sampling location were the same. This combination effectively doubled the number of observations that could be used to construct a model.

A comparison of these two estimates revealed the following (see Table 3-34):

1. Estimates extrapolated from a few (18) sampling dates underestimated the total numbers of larvae entrained annually (207,576,600) compared to the predicted mean number (431,637,627); and
2. In contrast, daily estimates (2,695,800) were within the predicted 95 percent confidence level (2.5 million to 9.6 million) provided by the Gaussian curve.

3.4.2.1 Summary and Conclusions--This analysis suggests that loss estimates provided in Tables 3-32 and 3-33 may reasonably approximate the real loss to the river system. The losses of larval shad and drum may not be significant because of the high fecundity of these species. Cooper Nuclear Station, however, appears to entrain large numbers of catostomid larvae. Consequently, it could possibly reduce annual recruitment to the commercial fishery (assuming that appropriate habitats are available for these larvae). However, this does not seem to be reflected in the commercial fisheries statistics.

3.4.3 Impingement of Juvenile and Adult Fish

Data on fish impingement studies at Cooper Nuclear Station discussed in this section were collected from July 1974 through December 1978. Sample size (i.e., number of hours) varied by month and year as did sampling period (i.e., nocturnal versus diurnal) (see Table 3-35). During the study period a total of 664 hourly samples were collected.

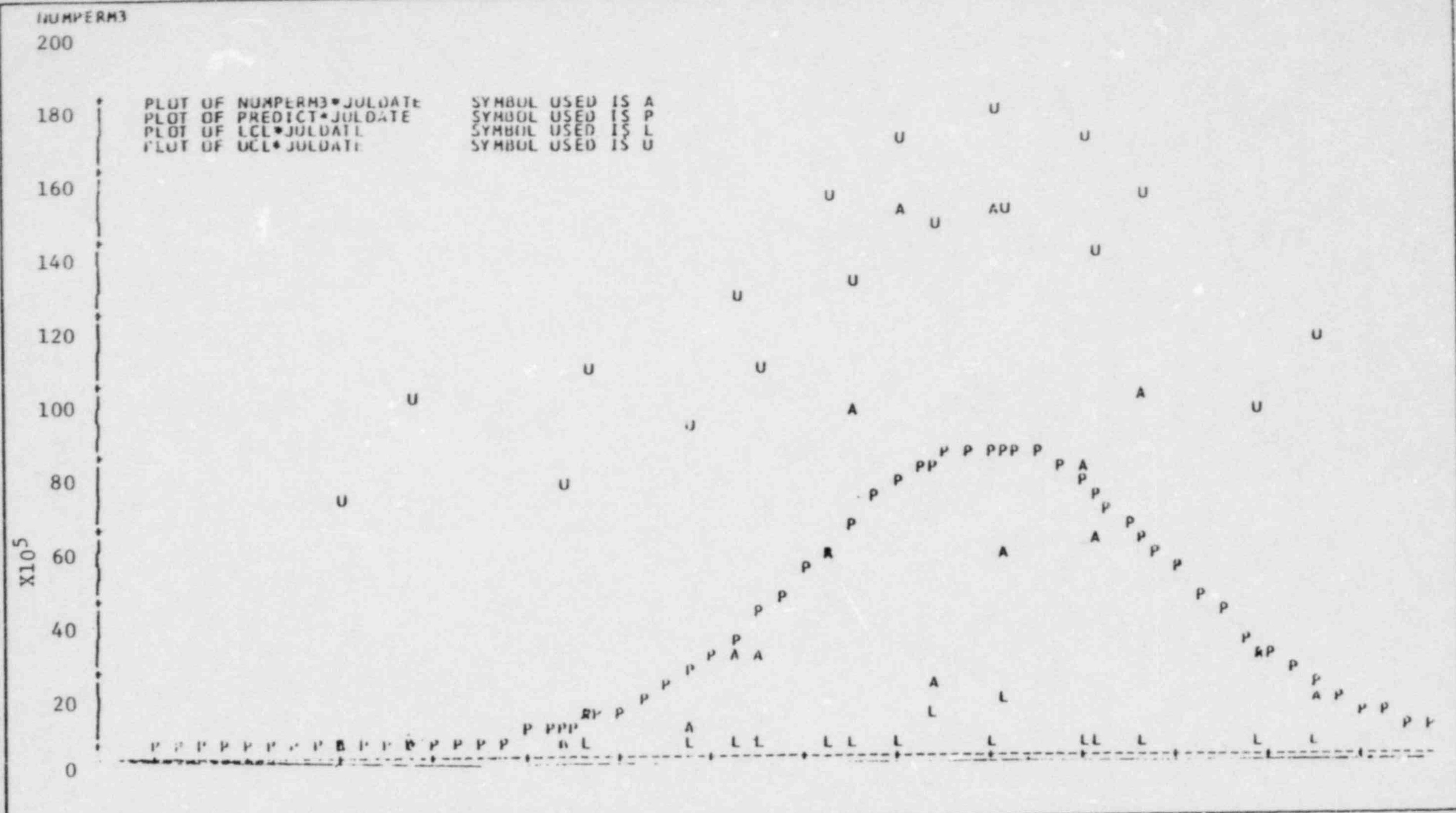


Figure 3-18
FISH ENTRAINMENT, GAUSSIAN CURVE, 1976

COOPER NUCLEAR STATION

Table 3-34. Statistically Predicted versus Calculated Total Entrainment of Larval Fish by Cooper Nuclear Station, 1977

	Predicted Seasonal Abundance	Predicted Daily Abundance	Observed Seasonal Abundance	Observed Daily Abundance
Upper Level 95% Confidence	697,838,328	9,692,199	----	----
Mean	431,637,624	5,994,967	207,576,600	2,695,800
Lower Level 95% Confidence	165,436,920	2,297,735	----	----

Source: ESE, 1981.

Table 3-35. Sample Size (Hours) for Fish Impingement, 1974 to 1978 Day/Night
Total

	1974	1975	1976	1977	1978
January	----	11/6 17	4/-- 4	8/10 18	1/1 2
February	----	7/5 12	1/3 4	10/10 20	0/2 2
March	2/0 2	1/2 3	4/3 7	11/12 23	2/1 3
April	3/1 4	14/8 22	10/12 22	10/11 21	0/2 2
May	12/4 16	11/8 17	5/5 10	11/11 22	1/1 2
June	12/6 18	6/6 12	8/9 17	11/11 22	1/1 2
July	13/6 19	2/5 7	10/12 22	10/9 19	0/2 2
August	14/8 22	2/3 5	11/12 23	8/12 20	0/3 3
September	12/4 16	6/11 17	8/9 17	6/7 13	0/2 2
October	16/8 24	----	----	8/4 12	1/1 2
November	12/7 19	0/3 3	6/7 13	11/10 21	0/3 3
December	10/3 13	5/7 12	11/12 2[illegible]	11/11 22	1/1 2
TOTALS	77/36 113	65/64 129	78/84 162	115/118 233	7/20 27

Source: ESE, Compiled from Reference Document Numbers 9 through 13.

At Cooper Nuclear Station, the traveling screens are back flushed with high pressure water. The materials washed from all the screens are collected in a common trough and carried to a pipe that discharges the material back to the river. Impingement samples were collected from the trough prior to entering the discharge pipe. Therefore, impingement samples were thought to be representative for all the intake screens. Station personnel collected the samples and identified the fish. Because identifications were not always to species level, the actual number of species impinged could not be determined. Impingement estimates used for this study were calculated by multiplying the average hourly impingement rate by the number of hours in that time period (e.g., nocturnal hours). These two time periods (day/night) were then added together to provide monthly impingement estimates. This method, of course, has limitations because of the following assumptions:

1. The rate of impingement is assumed to be constant for a period of 1 month.
2. The sampling event is assumed to be representative of the time period, i.e., nocturnal versus diurnal, and the month.

Conversely, sample size (N = 664 hours) over time is believed sufficient to demonstrate trends.

Gizzard shad, freshwater drum, and river carpsucker comprised the majority of the identified fish impinged during the study period (see Table 3-36). Other species included in the impingement data were carp, channel catfish, flathead catfish, and an unknown number of species included as unidentified minnows.

The fish impingement process at Cooper Nuclear Station appears to be nonselective for certain species and selective toward others. River carpsucker averaged 12.5 percent of the fish impinged and 23.6 percent of the river community (see Table 3-37). Gizzard shad averaged 48.7 percent of the impingement and 23.3 percent in the river.

Table 3-36. Summary of the Relative Abundance (Percent) of Fish Impinged at Cooper Nuclear Station, 1974 to 1978*

Species	Year				
	1974	1975	1976	1977	1978
Shovelnose sturgeon	<0.1	---	0.1	0.2	---
Paddlefish	<0.1	0.5	0.1	0.7	---
Longnose gar	<0.1	---	---	0.1	---
Shortnose gar	0.6	0.4	0.1	0.4	---
Unidentified gar	0.1	---	0.1	0.3	---
Gizzard shad	66.4	32.7	56.1	41.2	47.0
Goldeye	0.6	1.3	2.8	3.8	1.1
Carp	2.1	4.4	2.5	4.6	6.4
Unidentified minnows	0.9	6.2	3.0	2.6	10.9
River carpsucker	3.3	26.0	10.2	22.3	0.8
White sucker	---	---	0.2	---	---
Blue sucker	---	---	0.4	---	---
Bigmouth buffalo	---	1.6	0.3	0.8	0.4
Smallmouth buffalo	1.4	0.5	0.4	0.8	---
Unidentified buffalo	---	---	0.4	0.1	---
Unidentified suckers	---	---	---	0.2	---
Black bullhead	<0.1	0.5	0.1	0.1	0.8
Unidentified bullhead	<0.1	1.5	---	0.3	---
Channel catfish	0.4	1.6	2.2	1.1	1.9
Flathead catfish	0.4	0.9	0.8	1.2	0.4
Unidentified catfish	---	---	0.2	---	1.5
White bass	1.4	1.6	1.7	1.5	0.8
Green sunfish	---	0.1	---	---	---
Bluegill	0.4	0.5	0.8	0.5	0.4
Smallmouth bass	---	---	---	0.1	---
Largemouth bass	0.1	0.1	0.5	0.2	0.8
Crappie (*Pomoxis* spp.)	0.4	0.9	2.2	0.3	1.1
Unidentified sunfish	---	---	0.4	---	0.4
Sauger	<0.1	0.9	0.5	1.7	0.4
Freshwater drum	21.2	16.3	14.1	15.0	25.2
Unidentified	---	---	---	0.1	---

* Data for 1974 through 1978 from Bazata (1975), Coon (1976), Bliss (1977), and King 1978, respectively.

Source: Reference Document Number 13.

Table 3-37. Comparison of Average Impingement and River Community Composition of Selected Fish Species in the Missouri River Near Cooper Nuclear Station, 1974 to 1978

Species	Average Percent Impinged	Average Percent Collected by Electroshocking
Gizzard shad	48.7	23.3
River carpsucker	12.5	23.6
Carp	4.0	22.7
Goldeye	1.9	9.3
Freshwater drum	18.4	5.9

Source: ESE Compiled from Reference Document Number 13.

In contrast, carp comprised 22.7 percent of the river community, but only 4.0 percent of the impingement sample. A different trend is evident for freshwater drum. Drum comprised 18.4 percent of the impinged fish, but only 5.9 percent of the river community.

These data may then be roughly grouped into these categories:

1. Those species that are relatively abundant in both the river and impingement collections (gizzard shad, river carpsucker);
2. Those species that are abundant in the river, but are not so in impingement samples (carp); and
3. Those species that are abundant in the impingement samples, but are not so in the river (drum).

In addition to species selectivity, impingement at Cooper Nuclear Station is also size selective, being biased toward smaller fish. Fish impinged from 1974 through 1977 generally averaged (except goldeye) less than 150 mm and usually young-of-the-year or the Year I class (see Table 3-[illegible]). Adult fish impinged included a few individuals of several species (see Table 3-39).

Annual impingement was highest in 1974 (August to December) when an estimated total of 179,093 fish was impinged (see Table 3-40). This is presumably due to station start-up and curtain wall construction. The lowest impingement reported was for 1975 when 39,154 fish were estimated to have been impinged. Impingement rates generally were higher during May, declined in June, increased again in July, and then slowly declined through the rest of the year (see Figure 3-19). A notable exception to this trend occurred in 1974. In August 1974, the number of fish impinged was greater than the annual total for either 1975 or 1977. Impingement remained high for the rest of the year. Small gizzard shad (averaged 120 mm in length) comprised the bulk of the fish impinged during this period (see Table 3-41). It should also be noted that impingement was almost always higher during the nocturnal sampling than the diurnal period (see Table 3-40).

Table 3-38. Mean Lengths (mm) of Selected Species Impinged by Cooper Nuclear Station, 1974 to 1977

Species	Year			
	1974	1975	1976	1977
Gizzard shad	120	119	86	126
River carpsucker	135	87	106	104
Carp	126	154	144	147
Goldeye	243	275	196	254
Freshwater drum	76	118	114	108

Source: ESE Compiled from Reference Documents Number 10 to 12.

Table 3-39. Species Composition and Size Distribution of Fish Impinged on the Traveling Screens in the Intake Structure of Cooper Nuclear Station, January to December 1977

Species	Number	Length (mm) Mean	Length (mm) Range	Weight (g) Mean	Weight (g) Range
Shovelnose sturgeon	2	590	580-600	472	464-481
Paddlefish	7	806	700-900	>500	---
Longnose gar	1	550	*	450	---
Shortnose gar	4	405	280-480	228	114-310
Unidentified gar	3	183	110-260	51	7-96
Gizzard shad	442	126	30-295	45	1-360
Goldeye	41	254	85-350	194	6-456
Carp	49	147	25-500	110	2->550
Unidentified minnows	28	92	75-120	9	4-20
River carpsucker	239	104	30-350	35	1->540
Bigmouth buffalo	8	165	5-300	103	1-329
Smallmouth buffalo	8	164	50-355	144	1->500
Unidentified buffalo	1	90	---	9	---
Unidentified suckers	2	77	65-90	9	8-10
Black bullhead	1	60	---	1	---
Unidentified bullhead	3	85	80-90	6	2-9
Channel catfish	12	67	50-120	3	1-12
Flathead catfish	13	119	60-320	56	2-375
White bass	16	169	60-330	92	10-390
Bluegill	5	63	48-84	9	1-15
Smallmouth bass	1	70	---	5	---
Largemouth bass	2	103	70-135	17	2-32
Crappie (*Pomoxis* spp.)	3	104	90-111	13	8-30
Sauger	18	219	110-495	160	8->500
Freshwater drum	164	108	48-330	86	1->500
Unidentified species	1	65	---	1	---

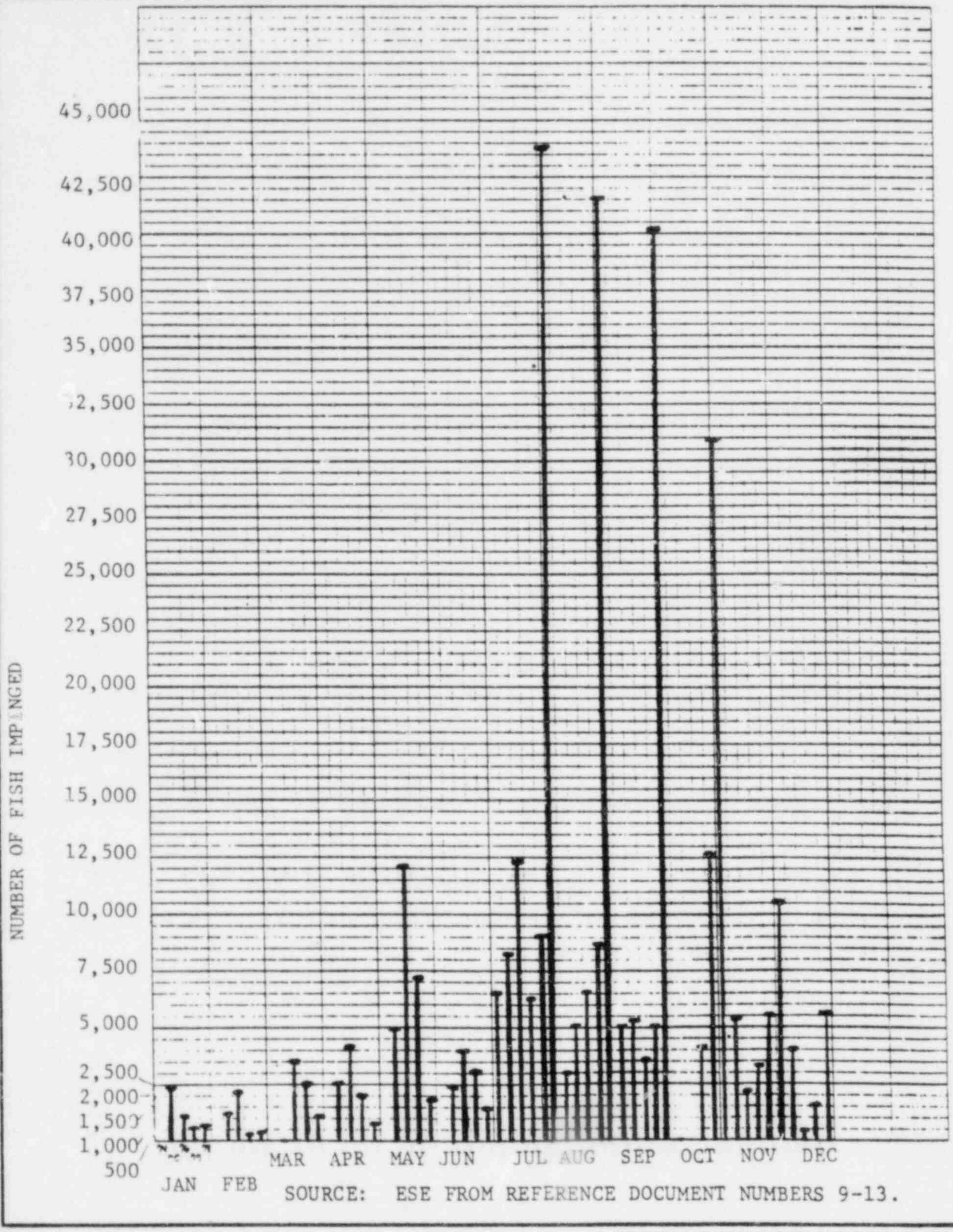
* Not Applicable.

Source: Reference Document No. 12.

Table 3-40. Monthly Estimated Fish Impingement, 1974 to 1978 $\frac{\text{Day/Night}}{\text{Total}}$

	1974	1975	1976	1977	1978
January	—	856/1,562 2,418	1,190/— 1,190	37/632 669	744/0 744
February	—	437/672 1,109	1,008/1,109 2,117	168/671 235	—/336 336
March	0/0 0	0/0 0	2,678/744 3,422	632/1,823 2,455	744/336 1,080
April	54/0 54	1,368/1,188 2,556	1,728/2,412 4,140	720/1,188 1,908	—/720 720
May	288/3,840 4,128	2,083/2,790 4,873	7,514/4,613 12,127	3,980/3,125 7,105	1,116/744 1,860
June	684/972 1,652	1,440/972 2,412	1,836/2,160 3,996	2,196/900 3,096	1,440/0 1,440
July	1,055/5,406 6,461	900/7,416 8,316	1,042/11,346 12,338	1,228/5,134 6,362	—/9,114 9,114
August	10,422/33,235 43,657	1,488/1,488 2,976	1,674/3,348 5,022	2,641/3,980 6,621	—/8,667 8,667
September	10,890/30,600 41,490	1,728/3,312 5,040	1,944/3,276 5,220	2,340/1,296 3,636	—/5,040 5,040
October	16,308/23,868 40,176	0/0 0	—	1,711/2,344 4,055	3,348/9,300 12,648
November	16,488/14,508 30,996	0/5,400 5,400	900/1,296 2,196	1,404/1,872 3,276	––/5,508 5,508
December	3,449/7,026 10,475	2,678/1,376 4,054	112/298 410	930/632 1,562	0/5,580 5,580
TOTALS	59,638/119,455 179,093	12,978/26,176 39,154	21,626/30,602 52,228	17,987/22,993 40,980	7,392/45,345 52,737
Total Sampling Periods (Hours)	106/47 153	65/64 129	78/84 162	115/118 233	7/20 27

Source: ESE, Compiled from Reference Document Numbers 9 through 13.



SOURCE: ESE FROM REFERENCE DOCUMENT NUMBERS 9-13.

Figure 3-19
FISH IMPINGEMENT GRAPH, 1974 TO 1978

COOPER NUCLEAR STATION

Table 3-41. Species Composition and Size Distribution of Fish Impinged by Cooper Nuclear Station, July to December 1974

Species	Length (mm)			Weight (gm)	
	Number	Mean	Range	Mean	Range
Shovelnose sturgeon	1	440.0	-*	310.0	-
Paddlefish	1	700.0	-	1,100.0	-
Lepisosteidae	4	390.0	200-500	293.3	240-400
Longnose gar	2	550.0	500-600	400.0	-
Shortnose gar	15	436.2	353-640	187.8	50-275
Gizzard shad	2,794	120.3	30-380	28.7	1-270
Goldeye	22	242.9	50-462	285.5	36-550
Cyprinidae	35	71.3	60-120	10.4	3-30
Carp	61	125.5	35-473	79.3	14-500
River carpsucker	139	135.3	50-496	107.6	3-550
Smallmouth buffalo	55	117.4	40-320	44.2	3-458
Ictaluridae	1	55.0	-	15.0	-
Black bullhead	1	60.0	-	Not Recorded	
Channel catfish	16	72.4	50-114	8.1	2-25
Flathead catfish	17	84.8	30-170	32.3	4-238
White bass	59	136.3	10-320	48.5	8-272
Bluegill	12	98.1	15-200	90.2	10-202
Largemouth bass	3	116.7	80-140	21.3	8-33
White crappie	9	96.7	50-200	41.8	2-110
Black crappie	2	115.0	50-180	90.0	-
Sauger	2	255.0	140-370	244.0	18-470
Freshwater drum	929	75.9	40-320	42.3	5-400
Average		112.8		38.4	

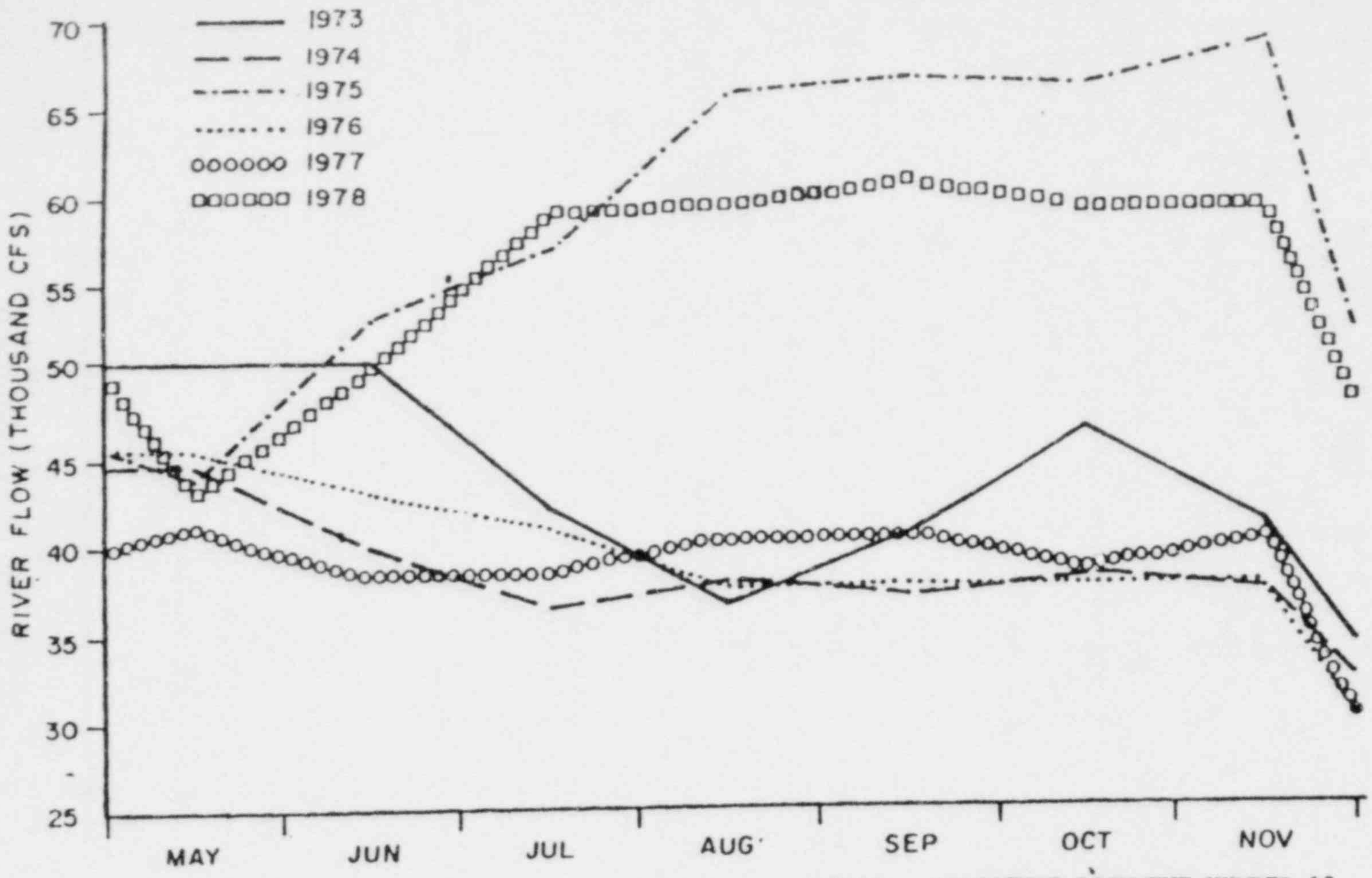
* Not Applicable.

Source: Reference Document Number 9.

Size and/or species selectivity of impinged fish is obviously related to cooling water intake velocity, fish swim speed, water temperature, and fish avoidance (day versus night) and fish behavior (i.e., habitat preference and movement). Intake velocities at Cooper Nuclear Station have never been measured, but have been estimated to vary from 2.5 fps at river flows, <11,000 cfs to 1.3 fps at approximately 32,000 cfs.[4] The lower the river flow, the greater the intake velocity. Approach velocities of 0.5 fps or less have been recommended to reduce the probability of impingement.[49] Periods of low flow near Cooper Nuclear Station generally occur between late November and March (see Figure 3-20). Comparisons of impingement rates during the period of low flow, however, only accounted for approximately 18 to 33 percent of the annual impingement (see Table 3-42).

In an attempt to relate impingement rate to several variables (e.g., number of circulating pumps, water temperature, intake velocity, etc.) using a stepwise regression analysis, it was revealed that among seven variables tested[50] the total flow of water through the plant appears to be the most significant factor governing fish impingement rate. However, both time of sampling (seasonality), and water temperature and dissolved oxygen combined were just as important as factors defining plant operation (number of pumps, intake velocity). These results do not explain cause/effect relationship but are indicative of interactions taking place.

Impingement rates of selected fish species were calculated to provide estimates of potential loss (see Table 3-43). Further, using available mortality data,[51] estimates were generated to predict losses to the river fishery (see Table 3-44). Inspection of these data indicated large potential losses for gizzard shad (see Table 3-44). The loss of gizzard shad may not be significant because they are a prolific species[45] that tend to overpopulate some waters to the detriment of other species. Hesse, et al.[51] concluded that shad and several



SOURCE: REFERENCE DOCUMENT NUMBER 13.

Figure 3-20
MEAN WEEKLY RIVER FLOW AT NEBRASKA CITY, NEBRASKA, 1973 TO 1978

COOPER NUCLEAR STATION

Table 3-42. Monthly and Annual Summary of Fish Impingement (Percent) at Cooper Nuclear Station, 1974 through 1978

	Percent Fish Impingement 1974 Through 1978				
	1974	1975	1976	1977	1978
June	0.9	6.2	7.7	7.6	2.7
July	3.6	21.2	23.7	15.5	17.3
August	24.3	7.6	9.6	16.2	16.4
September	23.1	12.9	10.0	8.9	9.6
October	22.4	0	----	9.9	24.0
November	17.3	13.8	4.2	8.0	10.4
December	5.8	10.4	0.8	3.8	10.6
January	----	6.2	2.3	1.6	1.4
February	----	2.8	4.1	0.6	0.6
March	0	0	6.6	6.0	2.0
April	0.003	6.5	7.9	4.7	1.4
May	2.3	12.4	23.2	17.3	3.5

Source: ESE, Compiled from Reference Document Numbers 9 through 13.

Table 3-43. Estimated Numbers of Selected Species Impinged by Cooper Nuclear Station, 1974 through 1978

	1974	1975	1976	1977	1978	Totals
Gizzard shad	115,041	12,803	29,300	16,834	24,786	198,764
Goldeye	1,040	509	1,462	1,557	580	5,148
Carp	3,638	1,723	1,306	1,885	3,375	11,927
River carpsucker	5,717	10,180	5,327	9,139	422	30,785
Bigmouth buffalo	---	626	157	328	211	1,322
Smallmouth buffalo	2,426	196	209	328	---	3,159
Channel catfish	693	626	1,449	451	1,002	4,221
Flathead catfish	693	744	418	492	211	2,558
White bass	2,426	626	888	615	422	4,977
Largemouth bass	173	39	261	82	422	977
Sauger	0	352	261	697	211	1,521
Freshwater drum	36,730	6,382	7,364	6,147	13,290	69,913

Source: ESE, Compiled from Reference Document Numbers 9 through 13.

Table 3-44. Estimated Number of Fish Impinged by Cooper Nuclear Station Which Would Have Been Recruited to the Missouri River Fishery

Species	1974	1975	1976	1977	1978
Carp	164	5	22	31	56
River carpsucker	163	101	114	195	9
Bigmouth buffalo	---	88	22	46	30
Channel catfish	35	59	105	33	73
Flathead catfish	29	36	18	21	9
Sauger	0	11	4	21	6

Estimated Percent Loss to Commercial Fisheries (1976) Due To Impingement by Cooper Nuclear Station

Species	Estimated Number Impinged	Commercial Fish Landing	Estimated Percent Loss To Commercial Fisheries
Carp	22	8,153	0.2
Channel catfish	105	2,382	4.4
Flathead catfish	18	500	3.6
Bigmouth buffalo	22	408	5.4

Source: ESE, 1981.

other species had maintained good yearly recruitment. Gizzard shad stocks were probably not affected by Cooper Nuclear Station.

Freshwater drum and river carpsucker also appeared to be potentially affected. Hesse, et al.[51] concluded that drum like shad demonstrated good yearly recruitment. However, their data indicated that river carpsucker populations may be stagnating, and it may be that station operation will reduce the stocks of river carpsucker. Data contained in the upper portion of Table 3-44 provide an estimate of the number of individuals lost to the river fishery per year because of impingement. The lower portion of this table estimates the number of individuals lost compared to the reported commercial catch for 1976. None of these impacts appear significant for Cooper Nuclear Station. However, El-Shamy[52] calculated a loss of 11 percent for bigmouth buffalo at Fort Calhoun Station. This study estimates a loss of 5.4 percent for Cooper Nuclear Station. Taken together, these two stations would reduce the river stock of bigmouth buffalo by 16 percent annually. This, however, is not reflected in the commercial catch (see Tables 3-26 and 3-27). These data indicate an increase in landings for buffalo (both big- and smallmouth), but a decline in the average weight of individuals.

3.4.3.1 Summary and Conclusions--The number of fish impinged at Cooper Nuclear Station was relatively high for some species (e.g., gizzard shad). However, no reduction in commercial landing was noted for commercially important species. Comparisons of preoperational and operational electrofishing data (see Table 3-24) indicated annual changes in relative abundance of gizzard shad, carp, river carpsucker, and goldeye. There were no obvious trends of major increases or declines through time among these populations. The remaining species (such as bigmouth buffalo, white bass) were collected in low numbers indicating sporadic occurrence in the study area. This apparently patchy distribution precludes further analysis for these species.

A reduction of the young-of-the-year and small fish by impingement could potentially result in reductions of the adult fish populations assuming given appropriate river habitats are available. Some species are impinged in much greater numbers than others. The two most abundant species in the impingement collections, the gizzard shad and the freshwater drum, are impinged in relatively large numbers even though the former species could become nuisance in future years. Since the majority of the gizzard shad impinged were young-of-the-year and juveniles, these fish were simply eliminated from the food chain of piscivorous species to a certain extent (they are probably preyed upon in the discharge zone). There has been a potential loss of bigmouth buffalo which is commercially valuable. However, that loss does not seem to influence the rate of recruitment of that species to the commercial fisheries. The commercial landings of bigmouth and smallmouth buffalo indicated an upward trend in the species abundance, however, a decline in average fish weight between 1974 and 1976 was evident. Neither of these two parameters could be related to station operations. Furthermore, no fishing statistics were available for the 1977 to 1980 period.

4.0 SUMMARY AND CONCLUSIONS

4.0 SUMMARY AND CONCLUSIONS

Cooper Nuclear Station does not alter the phytoplankton, periphyton, zooplankton, or benthic macroinvertebrate communities of the Missouri River. Some effects were noted for these groups, but they were confined to either minor seasonal differences or were spatially limited.

The station appears to entrain large numbers of catostomid larvae, but this loss is not reflected in the available commercial fisheries statistics. Large numbers of gizzard shad and freshwater drum are impinged annually by Cooper Nuclear Station, but neither of these species seem to be adversely affected. Bigmouth buffalo populations could potentially suffer losses, but as was the case with the other catostomids, commercial catches of bigmouth buffalo did not seem to be affected by station operation.

The following summary is provided for each trophic level.

Phytoplankton and Periphyton

Periphytic algal community composition was dominated by diatoms throughout the monitoring program. Few differences were detected for the first two years of the monitoring program. However, in 1976 when the discharge canal was sampled, a shift in species composition was noted. The shift involved two species of the diatom genera Navicula. During the summer period of highest absolute temperatures, one species (N. luzonensis) replaced another (N. tripunctata var. schizonemoides) as the dominant in the discharge and was relatively abundant at a location approximately 2.5 miles downstream from the discharge.[12] Based on the example of Navicula, the discharge of Cooper Nuclear Station may have slightly altered the natural distribution of the river periphyton community. There were no shifts or major changes observed in the phytoplankton community composition during the operational period.

Primary productivity measurements, determined by carbon fixation rates and chlorophyll a concentration, did indicate effects related to station operation. Sampling for these parameters was conducted monthly throughout the year and provided complete seasonal comparisons.

In general, these studies indicated that effects of condenser passage varied with season. Initial (7 hour) effects usually indicated slight stimulation during the winter and minor inhibition of productivity during the remainder of the year. There was also some evidence of a shift in community composition in samples collected from the discharge canal. These changes, at times, favored the more tolerant greens and blue-greens over the diatoms but were not consistent enough or of sufficient magnitude, to demonstrate major plant-related effects.

Zooplankton

There were no consistent trends in abundance that appeared to be station-related. Species composition has apparently remained consistent, and no major shifts in group dominance (i.e., Copepoda versus Cladocera versus Rotifera) occurred other than expected seasonal shifts.

Mechanical and, at times, thermal stress have acted concurrently to crop the Missouri River zooplankton by an amount that varied from less than 1 percent to slightly over 6 percent.

Benthic Macroinvertebrates

There appeared to be a station-related downstream stimulation of tubificid oligochaete densities. Comparisons of densities from artificial substrates indicated that densities of macroinvertebrates, with minor exceptions, were higher in the discharge canal than at river reference locations.

In summary, a general stimulation of the benthic community was noted. Few statistically significant differences were noted. Station-related effects appeared minor and usually localized.

Fish

Cooper Nuclear Station does not interrupt fish movement in the Missouri River, and the plume does not form a barrier. Tagging studies conducted

near Cooper and Fort Calhoun Nuclear Stations indicated random movement, with no apparent trends. Other studies have also indicated that fish will move into and out of thermal plumes.

Inspection of the data for the October to November period suggested that gizzard shad, carp, and, to a lesser extent, goldeye were the species that would most likely be impacted by cold shock because these species appeared to congregate in the discharge canal.

Potential alteration in fish feeding habits as a result of Cooper Nuclear Station operation was evaluated. Data on the feeding habits of several species indicated that the station had no significant impact on feeding habits and were typical for the same species found elsewhere.

Entrainment losses were highest for the gizzard shad and freshwater drum. Catostomid larvae also appear to be heavily entrained.

Gizzard shad and freshwater drum are impinged in relatively large numbers. Since the majority of the gizzard shad impinged were young-of-the-year and juveniles, these fish were simply eliminated from the food chain of piscivorous species. There appears to be a potential loss of bigmouth buffalo due to impingement. However, this loss was not reflected in the commercial fisheries statistics available.

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5.0 REFERENCES CITED

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APPENDICES

APPENDIX A

ENVIRONMENTAL TECHNICAL SPECIFICATIONS

APPENDIX B

TO

OPERATING LICENSE NO. DPR-46

FOR THE

COOPER NUCLEAR STATION

NEBRASKA PUBLIC POWER DISTRICT

DOCKET NO. 50-298

Date: JAN 1 8 1973

ENVIRONMENTAL TECHNICAL SPECIFICATIONS

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1.0 DEFINITIONS

Deicing - refers to melting of surface and frazil ice done by recirculating a portion of the condenser discharge water back to the intake structure through the ice control tunnel.

Intake Temperature - refers to the temperature at the inlet to the circulating water system.

Discharge Temperatures - refers to the temperature in the discharge canal.

ΔT Across Condenser - refers to the temperature difference between river ambient temperature and the discharge canal temperature.

Emergency Need for Power - shall mean any event causing authorized Federal officials to require or request that the Nebraska Public Power District supply electricity to points within or without the State of Nebraska or other emergencies declared by State, County, or Municipal authorities during which an uninterrupted supply of electric power is vital to public health and safety.

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.1 Thermal

Objective:

To limit thermal stress to the aquatic ecosystem and control water temperature within prescribed limits in order to minimize adverse thermal effects downstream of Cooper Nuclear Station.

2.1.1 Maximum ΔT Across Condenser

Specification

The limitations apply to the maximum temperature across the condensers during operation.

A. The maximum temperature across the condensers shall not exceed 18°F during normal operation. The maximum temperature shall not exceed 30°F when backwashing or fluctuations in power level occur.

B. The maximum temperature across the condensers shall not exceed 32°F during backwashing and 22°F at other times when a circulating water pump is down for for maintenance. Routine maintenance will not be scheduled during July or August or during periods when ice control is required.

3.0 MONITORING REQUIREMENT

3.1 Thermal

Objective:

To assure that thermal protection conditions including temperature difference across the condenser, discharge temperature, rate of temperature change, and temperature within a prescribed mixing zone are maintained within the technical specifications.

3.1.1 Maximum ΔT Across Condenser

Specification

Temperature across the condensers will be monitored once per shift during steady state operation utilizing condenser inlet and outlet RTD's with a 0-150°F range. The accuracy of the system and sensitivity of the RTD's are 1% and 0.1°F respectively.

Hourly temperature monitoring is required following changes in power level or during deicing and backflushing operations until the ΔT across the condensers are stable.

During recirculation for ice control, the temperature of the river water upstream from the ice-thawing tunnel outlets will be assumed to be 32°F unless temperature measurements are made. This temperature and the temperature obtained from the outlet

2.0 ENVIRONMENTAL PROTECTION CONDITION

Specification (Cont'd)

C. The maximum temperature across the condensers shall not exceed 30°F whenever a portion of the condenser discharge is recirculated to the inlet for ice control. Recirculation and backwashing will not be done concurrently.

Bases

Backwashing the main condenser is a necessity on a silt-laden river. Past experience at other generating stations on the Missouri River indicates that the condenser will require backwashing once per day. This process should take no longer than 1 hour.

Each of the four circulating water pumps should require maintenance every four years. However, with silt/sand-laden river conditions it could occur as often as once per year. Maintenance for one pump takes one week, thus three pump operation may be necessary for four weeks out of the year.

Surface and frazil ice are melted by recirculating a portion of the warm condenser discharge water back to the intake structure. This should occur intermittently from November through April, with primary use in December and January.

3.0 MONITORING REQUIREMENT

Specification (Cont'd)

RTD will be used to determine the ΔT which will be recorded hourly.

Bases

Temperature monitoring sensors at the inlet to and outlet from the condensers will provide the ΔT across the condensers.

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.1.2 Maximum Discharge Temperature

Specification

The limitation applies to the maximum temperature of the condenser cooling water discharge during operation. The condenser cooling water discharge temperature shall not exceed 103°F for more than 2 consecutive hours. If the water temperature exceeds 103°F for two hours, station power shall be reduced to the extent necessary to maintain the condenser cooling water discharge at 103°F or below, unless there is an emergency need for the lost power.

Bases

The 103°F maximum effluent temperature is established since the highest ambient river temperature of recent record at this location is 85°F.

3.0 MONITORING REQUIREMENT

3.1.2 Maximum Discharge Temperature

Specification

A mid-depth continous temperature recorder will be used in the discharge canal, and the peak temperatures in the discharge canal will be monitored hourly. The accuracy of the system and sensitivity of the temperature sensors are 1% and 0.1°F respectively. The continuous temperature recorder shall not be inoperative for a period exceeding 14 days.

As an alternate, when the continuous temperature recorder is inoperative, the temperature shall be obtained from a temperature indicator in the condenser discharge.

Bases

The placement of the temperature monitoring instrument in the discharge canal will give the temperature of the discharge water immediately before mixing with the receiving water. The placement of the temperature sensor at mid-depth in the discharge canal has been shown by temperature measurements at other depths in the canal to be representative of the discharge water entering the receiving stream.

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.1.3 Specified Mixing Zone

Specification

Plant operation will be controlled to prevent the thermal plume issuing from the plant exceeding 5°F ΔT in the summertime and 10°F ΔT in the wintertime outside a mixing zone not to exceed a width of 1/3 of the river and extending more than 7500 feet downstream from the discharge canal outlet. In addition, the thermal patterns created by station operation will be controlled so that the temperature outside the mixing zone will not exceed 90°F as a result of station operation. If these requirements cannot be met, plant power output will be curtailed to a level where the requirements can be met.

Bases

A mixing zone not to exceed a width of 1/3 of the river and extending a distance of 7500 feet downstream from the discharge canal outlet (∿ 45 acres) will, under most probable full power operating conditions, include the furthest downstream extent of the 10°F ΔT isotherm at the projected 7 day once-in-ten year minimum winter (Nov-Apr) flow of 8000 cfs and the 5°F ΔT isotherm at the projected 7 day once-in-ten year minimum summer (May-Oct) flow of 31,000 cfs.

3.0 MONITORING REQUIREMENT

3.1.3 Specified Mixing Zone

Specification

Thermal plume monitoring shall be conducted on a monthly bases for 1 year by boat (when river conditions permit) as described in Section 4.3.1. Correlations methods using station discharge temperature data (see Section 3.1.2) will then be used to calculate the 5°F ΔT and 10°F ΔT isotherms.

A continous recording temperature indicating device will monitor the river temperature at approximately 7500 feet downstream from the discharge canal outlet. This downstream monitor will be used until the correlation methods indicated above have been verified to be valid.

Bases

The 5°F ΔT and 10°F ΔT isotherms will be mapped and monitored to determine the area of the mixing zone. Ice conditions in the wintertime may curtail boat operations and may result in the loss of the 7500 foot monitoring station. Replacement of the 7500 foot monitoring station will be done when river conditions permit safe installation.

2.0 ENVIRONMENTAL PROTECTION CONDITION

Bases (Cont'd)

The 90°F temperature limitation is established because some species of this region cannot tolerate prolonged exposure to temperatures above 90°F. Since temperatures approaching 90°F only will occur a few weeks out of the year, no detrimental changes in population structure, food chain relationships or productivity are anticipated. Changes of this nature are expected in the immediate discharge area but such changes in a relatively small area of the receiving water are not expected to adversely affect the overall aquatic ecosystem.

2.1.4 Maximum BTU/hr.

Not applicable.

2.1.5 Rate of Temperature Change

Specification

The rate of change of the river water temperature due to cooling water discharge shall be limited to 2°F/hour at the mixing zone boundary. This limitation may be exceeded for brief periods as necessary to maintain protection of critical plant equipment and systems, and for certain safeguard operations which cannot be limited or negated by plant operation.

3.0 MONITORING REQUIREMENT

3.1.4 Maximum BTU/hr.

Not applicable.

3.1.5 Rate of Temperature Change

Specification

A mid-depth continous temperature recorder will be used in the discharge canal. (See 3.1.2) Temperatures in the discharge canal will be monitored and the rate of temperature change recorded hourly. This rate of temperature change will be correlated with the rate of temperature change at the mixing zone boundary. Accuracy and

2.0 ENVIRONMENTAL PROTECTION CONDITION

Specification (Cont'd)

These safeguard operations include automatic plant trips and manual plant trips initiated by licensed personnel in emergencies or other situations requiring such actions.

Bases

The limiting condition is established to minimize shock to the aquatic species of this region.

2.1.6 Heat Treatment of Circulating Water System

Not applicable.

2.1.7 Deicing Operations

See Section 2.1.1

3.0 MONITORING REQUIREMENT

Specification (Cont'd)

sensitivity are specified in Section 3.1.2. The downstream (7500 feet) monitoring station also will be used to verify this correlation.

Bases

Placement of the temperature monitoring instrument in the discharge canal will provide the rate of temperature change prior to mixing with the receiving water. A linear correlation of the rate of temperature change in the discharge canal and the mixing zone boundary is assumed.

3.1.6 Heat Treatment of Circulating Water System

Not applicable.

3.1.7 Deicing Operations

See Section 3.1.1

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.2 Hydraulic

2.2.1 Intake Velocity

Not Applicable. See Section 4.1.1.b.

2.2.2 Discharge Velocity

Not applicable.

2.2.3 Size of Mixing Zone

See Section 2.1.3

2.2.4 Maximum and Minimum Flow Restrictions

Not applicable.

2.2.5 Reservoir Drawdown

Not applicable.

2.2.6 Erosion

Not applicable.

3.0 MONITORING REQUIREMENT

3.2.1 Intake Velocity

Not applicable. See Section 4.1.1.b.

3.2.2 Discharge Velocity

Not applicable.

3.2.3 Size of Mixing Zone

See Section 3.1.3

3.2.4 Maximum and Minimum Flow Restrictions

Not applicable.

3.2.5 Reservoir Drawdown

Not applicable.

3.2.6 Erosion

Not applicable.

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.3 Chemical

Objective:

To insure that all chemical releases from the plant are controlled and diluted so as to not adversely affect public health, the natural aquatic environment, or the desirability of the water for domestic water supply usage.

Specification (General)

All plant chemical discharges except the heating boilers blowdown and the building heating/ventilation air washers and cooling tower blowdown shall be diluted by the plant cooling water effluent during release to assure that deleterious material concentrations shall be less than those which may affect public health, the natural aquatic environmental, or the desirability of the water for domestic water supply usage. Heating boiler blowdown and the building heating/ventilation air washers and cooling tower blowdown may be discharged directly to the Missouri River.

Bases

Requiring that plant chemical discharges of significant quantity or concentration be diluted by the plant cooling water system will assure that concentrations of chemical

3.0 MONITORING REQUIREMENT

3.3 Chemical

Objective:

To insure that all chemical releases from the plant are identified by species and quantity and are monitored and maintained within the technical specifications.

Specification (General)

A physical inventory of all identifiable chemicals, excluding spent laboratory reagents, discharged directly to the river, the settling basin, or discharge canal shall be maintained and submitted as part of the semi-annual report. In addition, monitoring of water in the discharge canal will be done by monthly sampling and analysis for copper, iron, potassium, sodium, chlorine, settable solids, dissolved solids and pH in accordance with Section 4.1.1.1.A.

Bases

The physical inventory of all identifiable chemicals, excluding spent laboratory reagents, discharged directly to the river, the settling basin, or the discharge canal

Bases (Cont'd)

effluents discharged to the Missouri River are maintained at values that will not adversely affect public health, the natural aquatic environment, or the desirability of water for domestic water supply usage. Because of the low toxicity of the chemical treatment employed and the small quantities released, the hearing boilers blowdown (~ 93 gal/day) and the building heating/ventilation air washers and cooling tower blowdown (~ 200 gal/month) can be discharged directly to the river without deleterious effects.

Water treatment at the make-up water treatment plant consists of adding the following chemicals:

93% H_2SO_4	-24 gal/day
50% NaOH	-116 gal/day
$Al_2\ (SO_4)_3$	-14 lbs/day
Nalco 720 Floculant Aid	-1.6 lbs/day
$Ca(OH)_2$	-660 lbs/day

After treatment, the chemicals are discharged to the settling basin where settling occurs and the clarified effluent is subsequently released to the discharge canal. The maximum estimated flow rate from the settling basin into the discharge canal is 25 gpm. The estimated quantities of chemicals released to the discharge canal and their concentrations are shown in Table 1.

Bases (Cont'd)

can be in the form of an estimation of discharge quantity by purchase order and inventory differential. The chemical monitoring provides assurance that concentrations of chemical effluents are maintained at acceptable low values.

Spent chemical reagents from the chemistry laboratories are not to be included in the semiannual reporting requirement because of their small quantities, insignificant concentrations in liquids released, and because they drain to treatment systems where they are appropriately processed prior to release to the discharge canal.

Table 1.

CHEMICALS DISCHARGED FROM MAKE-UP WATER TREATMENT PLANT SETTLING BASIN (TO DISCHARGE CANAL)

Discharge Canal Flow = 5.9191×10^9 lb/day (7.0992×10^8 gal/day)

Chemical Discharged		Concentration (ppm)			
Type	Amount (lb/day) (1)	Added to Discharge Canal (1)	Existing in River (Intake Water)-Average (2)	Resulting in Discharge Canal	Increase (% of Existing)
Dissolved Solids					
Ca	23	0.0038	60	60.0038	
Mg	21	0.0035	18	18.0035	
Na	276	0.0466	55	55.0466	
Cl	21	0.0035	18	18.0035	
SO_4	649	0.1096	159	159.1096	
SiO_2	15	0.0025	15	15.0025	
TOTAL	1005	0.1698	440	440.1698	0.0388%

1) Calculated
2) Based on published USGS Data 1957-1968 inclusive.
3) Nebraska Water Quality Standards, March 1, 1971. (CNS-ER page C-14-4)

Suspended, Colloidal, or Settleable Solids					
Turbidity	10 JTU	Not Measureable	153 JTU	153 JTU Depending on river turbidity	Not Measureable

2.0 ENVIRONMENTAL PROTECTION CONDITION

2.3.1 Biocides

Specification

a. Chlorine

The concentration of total residual chlorine from all combined sources in the discharge canal shall not be greater than 0.1 mg/liter.

b. Phenolic Amines

Not applicable

Bases

a. Routine use of chlorine will not be required to maintain condenser or service water system cleanliness. Routine use of hypochlorite is required for sewage treatment plant effluent sterilization. Hypochlorite is also used to sterilize the potable water from the make-up water treatment plant. The concentration of total residual chlorine from the sewage treatment plant will not exceed 0.1 mg/liter in the circulating water discharge canal and will therefore avoid deleterious effects on the aquatic biota.

b. A phenolic amine is added once every two weeks to the cooling towers of the building heating and ventilation water system at a

3.0 MONITORING REQUIREMENT

3.3.1 Biocides

Specification

a. Chlorine

Residual chlorine in the discharge canal will be measured and recorded monthly by the ortho tolidine oxalic acid method or its equivalent with a detection limit of 0.1 mg/liter.

b. Phenolic Amines

Phenolic amine biocides will be inventoried but not monitored.

Bases

a. The measurement of chlorine in the discharge canal will give the concentration immediately before mixing with the receiving river water.

b. A review of the biocide inventory records will allow a check on discharge quantities to insure that discharges are of insignificant concentration.

2.0 ENVIRONMENTAL PROTECTION CONDITION

Bases (Cont'd)

rate not expected to exceed 50 ppm in the system to control fouling.

The blowdown from this sytem amounts to approximately 200 gal/month to the roof drains and thence directly to the river. This biocide is of small quantity and concentration and will not be a significant discharge to the river.

2.3.2 Corrosion Inhibitors

Specification

Not applicable.

Bases

Corrosion inhibitors are used in the heating boilers, closed cooling water system, and the heating/ventilation air washers and cooling towers.

a. Heating Boilers

The feedwater to this system is demineralized water. The corrosion inhibiting solution is batch fed and contains $Na_3PO_4 \cdot 12H_2O$, Na_2SO_3, and Morpholine. Morpholine is added at a rate of approximately 50 ml/day to control pH of

3.0 MONITORING REQUIREMENT

3.3.2 Corrosion Inhibitors

Specification

Corrosion inhibitors will be inventored but not monitored.

Bases

A review of the corrosion inhibitor inventory records will allow a check on discharge quantities to insure that the discharges are of insignificant concentration.

Bases (Cont'd)

the condensate. The average daily discharge rate through the headwall structure to the Missouri River is 93 gal/day. The average daily concentrations of chemicals in the discharge are:

Sulfate	22 mg/liter
Sulfite	73 mg/liter
Sodium	82 mg/liter
Phosphate	33 mg/liter

Upon dilution with projected minimum river flows (8000 cfs) the concentration of each of these constituents will be approximately 3.7×10^{-6} mg/liter.

b. Closed Cooling Water System

The feedwater to this system is demineralized water. The planned corrosion inhibitor contains 55% $NaNO_2$ with lesser amounts of $NaB_4O_7.5H_2O$ and NaOH. A trace amount of MBT (mercaptobenzothiozole) is present for inhibition of copper corrosion. Batch feeding of the inhibitor is done as necessary. The average concentration in the system is 500 ppm. There are no planned blowdowns for this system.

Bases (Cont'd)

c. Building Heating and Ventilation Air Washers and Cooling Towers.

The system utilizes demineralized water. An inhibitor is batch fed as required, to maintain a concentration of 200-300 ppm in the system. The planned chemicals consist of an organic phosphonate (ammoniomethylene phosphonic acid), sodium methacrylate and zinc and NaOH for pH control. Blowdown of this system is approximately 200 gal/month to the roof drains and thence to the headwall structure and the Missouri River.

Since there is no planned blowdown for the closed cooling water system and the other discharges are of small quantity and occur intermittently for short durations, a release specification is not applicable.

2.3.3 Heavy Metals

Not applicable.

2.3.4 Solids

Specification

a. Colloidal or Settleable Solids

3.3.3 Heavy Metals

Monitoring for Cu, Fe, K and Na will be done in accordance with Section 4.1.1.1.A.

3.3.4 Solids

Specification

a. Colloidal or Settleable Solids

2.0 ENVIRONMENTAL PROTECTION CONDITION

Specification (Cont'd)

Turbidity from waste water shall not impart more than a 10% increase to the water in the discharge canal.

b. Dissolved Solids

The conductivity of the water in the discharge canal shall not increase by more than 10% as a result of plant discharges.

Bases

The limiting conditions are established to minimize the effects on the natural aquatic environment.

2.3.5 Hydrogen Ion

Specification

The hydrogen ion concentration in the discharge

3.0 MONITORING REQUIREMENT

Specification (Cont'd)

Turbidity shall be determined and recorded at the cooling water inlet and in the discharge canal monthly with a detection limit of 1.J.T.U. (or F.T.U. as appropriate).

b. Dissolved Solids

The specific conductance shall be determined and recorded at the cooling water inlet and in the discharge canal monthly by Method No. 154 of "Standard Methods for the Examination of Water and Wastewater," 13th Ed. Detection Limit 1 μmho/cm.

Bases

Monitoring turbidity and specific conductance at the cooling water inlet and in the discharge canal will provide the percentage increase in these parameters due to Station operation.

3.3.5 Hydrogen Ion

Specification

The pH shall be determined at the cooling

2.0 ENVIRONMENTAL PROTECTION CONDITION

Specification (Cont'd)

canal is to be maintained between 6.5 and 9.0 pH units. No single unit of discharge to change the water in the discharge canal more than 0.5 pH.

Bases

The limiting condition is established to minimize the effect on the natural aquatic environment.

2.3.6 Other Chemicals

Specification

Solid chemicals precipitated in holding ponds shall be removed periodically and used for land fill in accordance with appropriate state regulations.

3.0 MONITORING REQUIREMENT

Specification (Cont'd)

water inlet and in the discharge canal monthly by the glass electrode method with a detection limit of 0.1 pH unit.

Bases

Monitoring pH at the cooling water inlet and in the cooling water discharge canal will indicate the pH change due to station operation. Monthly sampling is based upon the maximum estimated flow rate from the settling basin to the discharge canal being 25 gpm. The discharge canal flow rate at full power will be 650,000 gpm. The change in hydrogen ion concentration in the discharge canal resulting from the settling basin effluent is not expected to be detectable.

3.3.6 Other Chemicals

Not Applicable.

2.0 ENVIRONMENTAL PROTECTION CONDITION	3.0 MONITORING REQUIREMENT
Bases The solids removed from the holding pond will contain sand and silt, calcium sulfate and carbonate -- these are natural constituents of the area and should have no adverse effect as land fill.	

4.0 Environmental Surveillance and Special Studies

4.1 Biological

4.1.1 Aquatic

4.1.1.1 Surveillance, Study, and Evaluation Programs

Objective

Preoperational monitoring studies have been conducted since 1969 at Cooper Nuclear Station on the Missouri River for the Nebraska Public Power District by Industrial Bio-Test Laboratories, Inc. Data from these studies served as a basis for development of the operational monitoring program described herein. Comparisons between preoperational and operational data will be made by NPPD or its consultants to evaluate the effects of Station operation on the aquatic environment of the Missouri River in the vicinity of the Cooper Nuclear Station.

Study Plan

The operational monitoring program provides a thorough examination of the aquatic ecosystem of the Missouri River in the vicinity of the Cooper Nuclear Station. Specific study areas include the effects of condenser passage and entrainment on zooplankton and phytoplankton (Section 4.1.1.3), and a measure of the impingement of fish on intake structures (Section 4.1.1.2); the monitoring of temperature and other physical parameters; the monitoring of water quality including chemical and bacteriological parameters; and the monitoring of zooplankton, phytoplankton, periphyton, aquatic macroinvertebrates, and fish populations.

A map of the study area showing sampling locations is presented in Figure 1. Sampling locations may change slightly as characteristics of the thermal plume are better defined.

The frequency of field sampling and sampling locations for each area of investigation are presented in Table 2. Sampling will be conducted monthly and in general be confined to the months of May through November. Entrainment and water quality studies will be continued at the intake and discharge sampling locations throughout the year.

The operational monitoring program is such that sampling frequency and analyses can be increased or decreased depending on the results obtained in the continuing program.

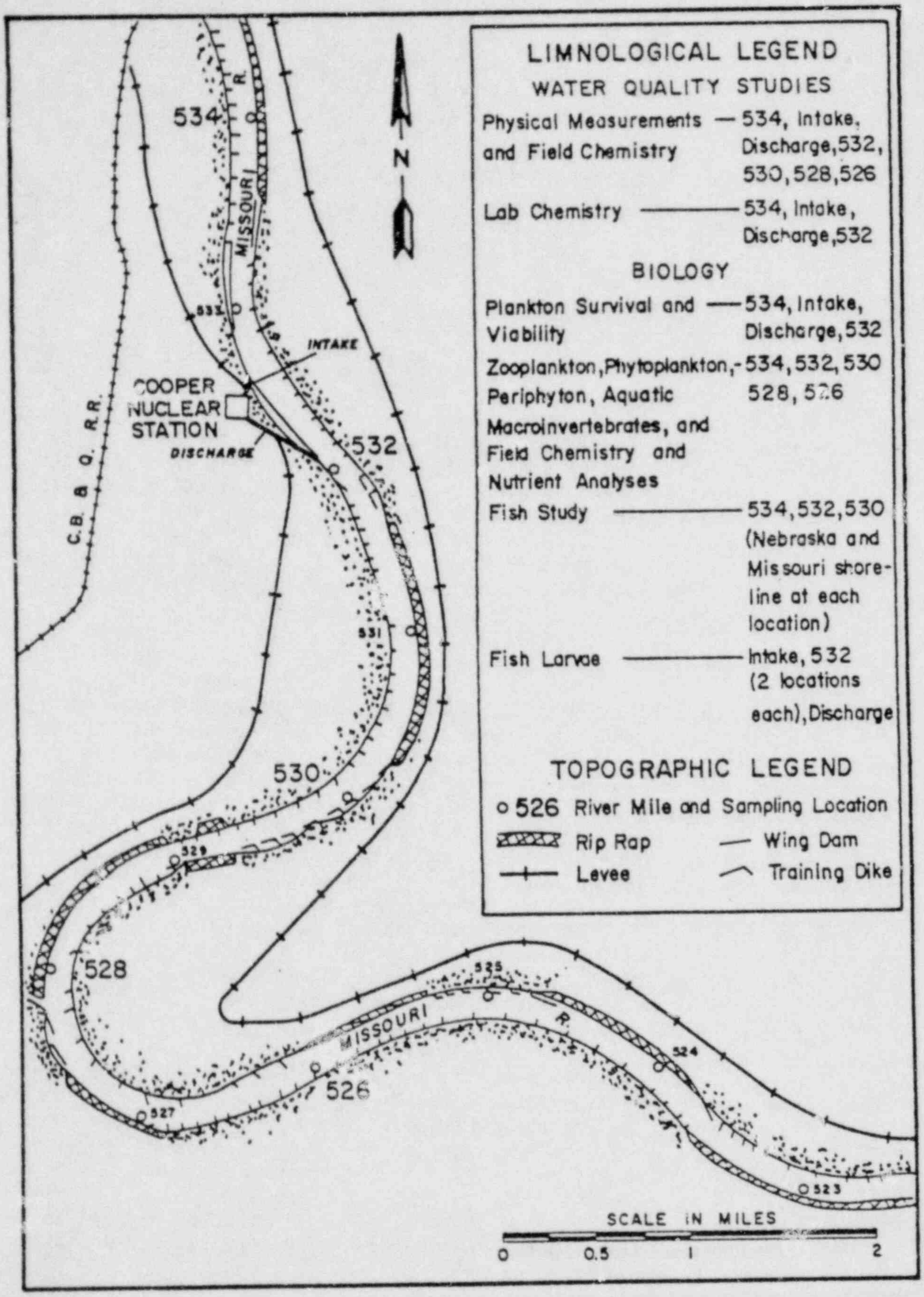

FIGURE I. SAMPLING LOCATIONS IN THE VICINITY OF THE COOPER NUCLEAR STATION

Table 2. Field sampling schedule for operational monitoring program at Cooper Nuclear Station

	Location						
	RM 534	Intake	Discharge	RM 532	RM 530	RM 528	RM 526
Physical Measurements and Field Chemistry (monthly)[a]	X	X	X	X	X	X	X
Laboratory Chemistry (monthly)[a]	X	X	X			X	
Zooplankton Survival (monthly)[a]	X	X	X	X			
Phytoplankton Viability (monthly)[a]	X	X	X	X			
Phytoplankton Cell Counts and Identification (monthly May-November)	X			X	X	X	X
Zooplankton Identification (monthly May-November)	X			X	X	X	X
Periphyton (monthly June-November)	X			X	X	X	X
Aquatic Macroinvertebrates (June, August, October)	X			X	X	X	X
Field Chemistry and Nutrient Analyses (monthly May-November)	X			X	X	X	X
Fish Study[b] (monthly May-November)	X			X	X		
Fish Larvae[c] (twice each month May, June, July)		X	X	X			
Fish Impingement (monthly)[a]		X					

[a] Sampling restricted to intake and discharge locations during the winter months.
[b] Sampling conducted at Nebraska and Missouri shoreline at each location.
[c] Sampling conducted at two locations in the vicinity of the intake and RM 532.

Specification

A. Water Quality Studies

Duplicate water quality samples for laboratory analyses (Table 3) will be collected monthly (May-November) from four locations: RM 534, in the immediate area of the intake, in the discharge canal and at RM 528. Sampling will be restricted to the intake and discharge locations during the remainder of the year. Physical measurements (Table 4) and field analyses including dissolved oxygen, pH, total alkalinity, and turbidity will be performed at seven locations: RM 534, intake, discharge, RM 532, RM 530, RM 528 and RM 526. Field chemistry and nutrient analyses (Table 5) will also be performed at the appropriate locations as part of the biological sampling program.

Instrumentation and methods for physical measurements are listed in Table 4. Analytical methods, references, preservation techniques and detection limits are presented in Table 6.

B. Biological Studies

1. Phytoplankton

Duplicate samples for phytoplankton analyses will be collected monthly (May-November) near the surface with a Kemmerer sampler at RM 534, 532, 530, 528, and 526. Analyses will consist of cell counts to determine abundance and diversity of species.

2. Zooplankton

Duplicate samples for zooplankton analyses will be collected monthly (May-November) with a Miller plankton sampler equipped with a #10 (153 μ mesh) plankton net at RM 534, 532, 530, 528, and 526. Analyses will be made to determine abundance and seasonal occurrence of zooplankton species.

3. Periphyton

Floating artificial substrates for periphyton (attached algae) will be anchored at suitable locations near RM 534, 532, 530, 528, and 526 to permit colonization of attached algae. A Ryan temperature recorder will be fastened near each substrate to provide a continuous record of water temperature. Monthly

Table 3. Laboratory analyses, water quality study.

1.	Ammonia	17.	Specific conductance
2.	Nitrate	18.	Copper
3.	Nitrite	19.	Cyanide
4.	Total organic nitrogen	20.	Fluoride
5.	Soluble orthophosphate	21.	Iron
6.	Total phosphorus	22.	Manganese
7.	Silica	23.	Methylene blue-active substances
8.	Total coliform bacteria	24.	Threshold odor
9.	Fecal coliform bacteria	25.	Phenols
10.	Fecal streptococci bacteria	26.	Potassium
11.	Biochemical oxygen demand	27.	Sodium
12.	Chemical oxygen demand	28.	Total dissolved solids
13.	Total organic carbon	29.	Total suspended solids
14.	Calcium	30.	Sulfate
15.	Chloride	31.	Total sulfide
16.	True color	32.	Zinc
		33.	Chlorine

Table 4. Physical measurements, instruments, and methods.

Parameter	Instrument or Method and Reference
Air Temperature, Wet and Dry Bulb	Bendix Psychrometer Model 566 (±0.1°C)
Relative Humidity	Bendix Centrigrade Psychrometer Slide Rule
Wind Velocity	Dwyer Wind Meter
Wind Direction	Field Observer
Cloud Cover	Field Observer
Water Temperature	Whitney Model TC-5A Thermistor/ Thermometer (±0.1°C)
Current Velocity	Gurley Current Meter (±0.1 m/s)

Table 5. Field chemistry and nutrient analyses associated with biological sampling at RM 534, 523, 530, 528, and 526.

1. Water temperature	7. Nitrate
2. Dissolved oxygen	8. Nitrite
3. pH	9. Soluble orthophosphate
4. Total alkalinity	10. Total phosphorus
5. Turbidity	11. Silica
6. Ammonia	

Table 6. Analytical methods for chemical parameters.

Parameter	Method and Reference	Preservation Techniques	Detection Limit
Alkalinity, total	Method 102[a]		1 mg/1-$CaCO_3$
Ammonia	Gas diffusion electrode[b]	$HgCl_2$[c]	0.01 mg/1-N
Bacteria, total coliform	Method 408A[a]	Sterile[d]	0 organisms/100 ml
Bacteria, fecal coliform	Method 408B[a]	Sterile[d]	0 organisms/100 ml
Bacteria, fecal streptococci	Method 409B[a]	Sterile[d]	0 organisms/100 ml
Biochemical oxygen demand (5-day)	Method 219[a]	BOD water, sealed water refrigerated	0.5 mg/1
Calcium	AAS/DA[e]	HNO_3[f]	0.1 mg/1
Chemical oxygen demand	Low level method[g]	Glass container refrigerated	0.1 mg/1
Chloride	Mercuric nitrate method 112B[a]	Plastic container	0.5 mg/1
Color, true	Colorimetric method 118[a]		1 unit
Conductance specific	Method 154[a]		1 µmho/cm
Copper	AAS/Chelation[h]	HNO_3[f]	0.1 µg/1
Cyanide	Method on pg. 41[g]	NaOH to pH 11, refrigerated	
Fluoride	Specific ion electrode[b]		0.01 mg/1
Iron	AAS/Chelation[h]	HNO_3[f]	1 µg/1
Manganese	AAS/Chelation[i]	HNO_3[f]	1 µg/1
Methylene blue-active substances	Method 159[a]	Glass container refrigerated	0.025 mg/1

Table 6. Continued.

Parameter	Method and Reference	Preservation Techniques	Detection Limit
Nitrate	Brucine method 213C[a]	$HgCl_2$[c]	0.01 mg/l-N
Nitrite	Sulfanilamide method[j]	$HgCl_2$[c]	0.2 µg/l-N
Odor, threshold	Method 136[a]	Glass container refrigerated	-
Organic carbon, total	Beckman Carbonaceous Analyzer	HCl to pH 2	1 mg/l
Organic nitrogen, total	Method 135[a] and phenate method 132C[a]	$HgCl_2$[c]	0.01 mg/l
Orthophosphate, soluble	Ascorbic acid method[j]	Filtration[k]	1 µg/l-P
Oxygen, dissolved	Dissolved Oxygen Meter, standardized by method 218B[a]	Measured at sampling location	0.1 mg/l
Oxygen, saturation	Calculated from D.O. and temperature data using Table 218(1)[a]		Expressed as percent
pH	Glass electrode method 144A[a]	Measured at sampling location	0.1 pH
Phenols	Methods 22B + C[a]	$CuSO_4$, H_3PO_4 to pH 4.0, refrigerated	1 µg/l
Phosphorus, total	Method 223C[a] then ascorbic acid method[j]		1 µg/l-P
Potassium	AAS/DA[e]	HNO_3[f]	5 µg/l
Residue, filtrable	Method 148B[a]		1 mg/l
Residue, Nonfiltrable	Method 148C[a]		1 mg/l

Table 6. Continued.

Parameter	Method and Reference	Preservation Techniques	Detection Limit
Silica	Method 151C[a]		0.01 mg/l
Sodium	AAS/DA[e]	HNO_3[f]	2 µg/l
Sulfate	Turbidimetric method 156C[a]	Filtration prior to analysis	5 mg/l
Sulfide	Specific ion electrode[b]	Zinc acetate and NaOH	4 µg/l
Turbidity	Hach Model 2100A Turbidimeter		1 J.T.U.
Zinc	AAS/Chelation[h]	HNO_3[f]	1 µg/l
Organic carbon, total, bottom sediment	Oxidation method	Refrigerated	100 mg/kg

a A.P.H.A., A.W.W.A. and W.P.C.F. 1971. Standard Methods for the Examination of Water and Wastewater. 13th ed. Am. Public Health Assn. Washington, D.C. 874 pp.
b Orion Research, Inc. 1970. Instruction Manual, Cambridge, Massachusetts.
c 40 mg $HgCl_2$ added to one liter of sample, refrigerated. Howe, L. H. III, and C. W. Holley. 1969. Comparisons of mercury (II) chloride and sulfuric acid as preservatives for nitrogen forms in water samples. Environ. Sci. Technol. 3:471-481.
d Sterile conditions, refrigerated, with 1 ml/l 10% $Na_2S_2O_3$ added.
e Atomic Absorption Spectrophotometery/Direct Aspiration.
f 5 ml concentrated HNO_3 added to two liters of sample.
g Environmental Protection Agency. 1971. Methods for Chemical Analysis of Water and Wastes. Water Quality Office, Analytical Control Laboratory, Cincinnati, Ohio. 312 pp.
h Fishman, M. J. and M. R. Midgett. 1968. Extraction techniques for the determination of cobalt, nickel and lead in freshwater by atomic absorption. p. 230-236. In: R. F. Gould (ed.), Trace Inorganics in Water. Amer. Chem. Soc., Washington, D.C.
i Personal communication, M. J. Fishman, U.S. Geological Survey, Denver, Colorado, October 1970.
j Strickland, J. D. H. and T. R. Parsons. 1968. A practical Handbook of Seawater Analysis. Bull. Fish. Res. Bd. Canada. 167. 311 pp.
k Immediate filtration (Millipore HA 0.45 µ), refrigerated.
l Black C. L. 1965. Methods of Soil Analysis, Vol. II. Amer. Society of Agronomy, Vol. 9, Series in Agronomy. Madison, Wisconsin. 1572 pp.

(June-November) samples of periphyton will be collected. Analyses will be made to determine the relative abundance of species present. Biomass (ash-free weight) of the periphytic community will also be determined.

4. Aquatic Macroinvertebrates and Benthic Organisms

The macroinvertebrate component of the "aufwuchs" community will be sampled at five locations (RM 534, 532, 530, 528, and 526) beginning in April using substrates similar to those described by Hilsenhoff (1971). These samples will be collected at two month intervals (June, August, and October) and identified to the lowest positive taxonomic category, usually genus or species. The total number of taxa and diversity will also be determined. Triplicate benthos samples will be collected concurrently using a Ponar dredge behind wing dams near the same five locations. Bottom sediment samples from these locations will be analyzed for total organic carbon. Sediment types will be visually determined.

Field Chemistry and nutrient analyses (Table 5) will be conducted as part of the phytoplankton, zooplankton, periphyton and aquatic macroinvertebrate sampling program.

5. Fisheries Study

Sampling for fish population and life history studies will be conducted near RM 534, 532, and 530. Samples will be collected from both the Nebraska and Missouri shorelines in the vicinity of each river mile location.

Fish will be sampled monthly (May-November) using the following techniques:

a. Electroshocking

A boat-mounted electroshocker is the most effective tool for collection of fish in the shallow water areas. Each fish that is collected will be measured and weighed; scales will be taken from selected individuals, and certain individuals will be fin-clipped and returned to the river. This will allow for the return of most fish to the river alive; however, it will be necessary to sacrifice some fish for stomach analysis and gonadal inspection. All fish collected will be examined for the occurrence of external parasites and diseases.

b. Seining

A seine (25 ft x 6 ft x 1/4" mesh) will be used to collect minnows and the young of other species. Sampling locations will be along the same locations used for electroshocking. Samples will be preserved in 10% formalin and returned to the laboratory for identification and measurement.

Fish larvae samples will be collected twice a month during periods of peak larval drift (May-July). A total of five locations will be sampled; two in the vicinity of the intake, one in the discharge canal, and two near RM 532.

An analysis of fish trapped in the plant intake structure and collected from the intake screens will be conducted 5 days per week to determine the types of species impinged, physical condition, numbers collected, and individual sizes and weights. See Section 4.1.1.2.

Bases

An assessment of the environmental effects of the operation of Cooper Nuclear Station will be made.

Results of the operational studies conducted at the Cooper Nuclear Station will be compared with the data collected during preoperational studies. Statistical analyses will be performed on all data sets when such analyses are appropriate aids in making inferences.

4.1.1.2 Plant Cooling Water Systems Fish Entrapment Limits

Objective

To establish a requirement for the monitoring of fish entrapment and to specify corrective action to reduce the environmental impact of this aspect of plant operation to its lowest practicable limit.

Specification

A. Fin fish trapped in the plant intake structure of Cooper Nuclear Station shall be determined one hour per day for a minimum of five days per week at random times including nocturnal periods. A record of each sampling period including time and an analysis

of entrapped fish by species, size, weight, quantity, and physical condition shall be maintained by the applicant or his consultant during the first year of operation.

B. If the quantity or type of fin fish is determined to be of significance or to have a significant detrimental impact on the propagation of fin fish the following steps will be taken:

1. The appropriate State and Federal agencies having responsibility for fisheries will be consulted.

2. Plans for corrective action will be developed.

3. A written notification within 10 days to the Director, Region IV Regulatory Operations with a copy to the Deputy Director, Reactor Projects outlining corrective steps being developed.

C. If the quantity of entrapped fin fish is unexpectedly or unusually large, immediate action will be initiated to reduce the entrapment rate pending a detailed review. Immediate action will consist of power reduction to reduce entrapment unless there is an emergency need for power.

Bases

The specified study will provide a basis for determining if fish entrapment protection conditions and monitoring requirements are appropriate for inclusion in Sections 2.0 and 3.0 of the technical specifications.

4.1.1.3 Monitoring of the Effects of the Condenser Cooling Water System on Plankton Organisms

Objective

To determine the thermal and mechanical effects of the condenser cooling water system in all months of the year on the dominant members of the phyto- and zooplankton that are present in the intake waters.

Specification

A. Zooplankton Survival

Single samples will be collected at the upstream (RM 534) and downstream (RM 532) sampling locations, while duplicate samples will be collected at the intake and discharge locations. Samples will be collected near the surface with a filter-pump system similar to that used by Icanberry (1972). A #10 mesh (153 μ) filter will be used in the filter-pump system to collect a representative sample. Samples will be maintained at intake water temperature, and survival analyses performed within 10 minutes and at 4 hours after collection.

Each sample will be concentrated to a 100-200 ml volume with a #20 mesh (80 μ) Nitex tipped pipette. A subsample of 0.5-1.0 ml will be taken from the concentrated sample with an automatic pipette, placed in a compartmentalized Petri dish, and examined under a sterozoom microscope. Zooplankton will be recorded as "motile" and "non-motile" because of recovery from temporary shock experienced during condenser passage. The criteria for determining non-motility will be the absence of appendicular and visceral movement upon probing. The term mortality will denote those organisms which fail to recover after 4 hours of observation. At the conclusion of the survival analyses, the zooplankton organisms will be preserved in a 3% formalin solution and identified to the lowest positive taxa according to Brooks (1957, 1966), Wilson and Yeatman (1966), Czaika and Robertson (1968), and Gannon (1970).

To obtain accurate survival data, 10-30 organisms will be separated from each subsample and a minimum of 150 organisms separated from each sample. A minimum of 150 organisms are separated to obtain consistencies between motile and non-motile counts from the same sampling site.

B. Phytoplankton Viability

Composite samples for determining phytoplankton viability will be collected near the surface with a Kemmerer water sampler at the same locations used for zooplankton survival studies. The composite samples will be maintained at intake water temperature for determination of phytoplankton species composition, chlorophyll a concentrations, rates of carbon fixation, and nutrient analyses.

Phytoplankton species composition will be determined initially at all four sampling locations and 24 and 72 hours after collection for the intake and discharge samples. Chlorophyll a concentrations and rates of carbon fixation will be determined at intervals of 3, 24, 48 and 72 hours after collection.

Cell counts and identification to genus or species will be made using techniques described by Vollenweider (1969) and Holland (1969). Chlorophyll a concentrations will be determined using fluorometric techniques described by Lorenzen (1966). Rates of carbon fixation will be estimated with the light-dark bottle ^{14}C method (Strickland and Parsons 1968; Parkos et al. 1969; and Wetzel 1964).

To check the possibility of nutrient depletion for phytoplankton viability studies, the following water quality parameters will be measured initially and 72 hours after sample collection at each location: ammonia, nitrate, nitrite, total phosphorus, soluble orthophosphate, and silica. In addition to these analyses, field measurements of water temperature, dissolved oxygen, pH, total alkalinity, and turbidity will be made initially and 72 hours after sample collection. Analytical procedures for these parameters can be found in the water quality section (4.1.1.a).

Bases

The specified study will be an extension of the preoperational study of selected planktonic organisms common to the Missouri River. The extension will emphasize the analysis of samples taken in the field using the laboratory techniques and equipment developed in the preoperational studies. This study will terminate in two years if the results demonstrate no deleterious effects.

4.1.1.4 11-Agency Study

An 11-agency group, coordinated by the Nebraska Game and Parks Commission, has been formed to evaluate postoperational effects of both the Cooper and Ft. Calhoun Stations. The agencies are:

Bureau of Sport Fisheries and Wildlife
Iowa Conservation Commission
Kansas Forestry, Fish and Game Commission
Nebraska Department of Environmental Control
Nebraska Game and Parks Commission
Nebraska Public Power District

U. S. Army Corps of Engineers
U. S. Environmental Protection Agency - Water Quality
U. S. Geological Survey
University of Nebraska
Omaha Public Power District

The three areas of major attention are: 1) temperature and chemistry, 2) fish and 3) macroinvertebrates and periphyton. Present plans call for a 2-year postoperational collection and evaluation program, with periodic reviews of the program and publication of progress and final reports.

Preoperational studies were begun in 1970, but the Joint Agency Study, except for phytoplankton, has been suspended until the plant becomes operational. Efforts are being made to exchange and compare data with the Nebraska Game and Parks Commission.

4.1.2 Terrestrial

Not applicable.

4.2 Chemical

See Section 4.1.1.1.

4.3 Physical

4.3.1 Aquatic

Thermal Plume Mapping

Objective

To define the 3-dimensional extent and isotherm structure of the thermal plume under varying operating and river flow conditions and to establish a basis for the correlations method (Section 3.1.3) of monitoring the thermal plume to assure that water temperatures are within the prescribed limits of the mixing zone.

Specification

Thermal plume monitoring shall be done on a monthly basis (when river conditions permit). Detailed temperature measurements will be made to define the 3-dimensional extent and isotherm structure of the thermal plume. Temperature measurements will be conducted

along preselected transects. A thermistor accurate to 0.1°C will be used to obtain the temperature at the surface and at one meter intervals to the bottom. Measurement locations will be determined by two shore based transepts using triangulation. The monitoring program shall incorporate consistent timing and sampling station relocation so as to reduce the stochastic variability of observations. The detailed monitoring program shall be submitted for staff review and approval prior to full power or commercial operation of the station.

Associated physical studies will be conducted in conjunction with the temperature measurements. These include a determination of the amount of heat discharged and the plume densometric Fronde Number. Velocity measurements will be obtained with a combination of drogues and deck readout flowmeters. Time-temperature relationships will be determined by use of recording thermistors mounted on drogues. Measurements of pertinent meteorological parameters will be made as wind velocity, air temperature, relative humidity and sky cover. The jet and far field velocity structure of the plume will be determined (i.e., indirect velocity by induced momentum of the plume). The plume temperature and velocity data will be used to determine the time-temperature relationship for organisms entrained into the thermal plume.

Bases

The 5°F ΔT and 10°F ΔT isotherms will be mapped to determine the area of the mixing zone. Mixing zone isotherms will be correlated with station discharge temperature and other variables. Appropriate correlations models will be developed to allow calculation of plume isotherms based upon discharge temperatures. A downstream monitor will be used until the correlations method indicated above has been verified to be valid.

4.3.2 Terrestrial

Not applicable.

4.3.3 Aerial

Not applicable.

4.4 Radiological

Objective

To provide the necessary information for evaluation of radiological effects on the environment.

5.0 Administrative Controls

Objective

The administrative section describes the administrative controls and procedures necessary to implement the environmental technical specifications.

Specification

5.1 Review and Audit

The Station Operation Review Committee (SORC) of Cooper Nuclear Station is the group assigned to be responsible for checking, inspecting, or otherwise verifying that an activity has been correctly performed. The review function will be performed by personnel directly involved in the activity under review.

The audit function will be performed by the NPPD Safety Review and Audit Board (SRAB).

Review and audit functions will be defined for the following areas:

a. Results of the environmental monitoring programs prior to their submittal in each semiannual Environmental Monitoring Report. See Section 5.4.1.

b. Proposed changes to the environmental technical specifications and the evaluated impact of the change.

c. Proposed changes or modifications to plant systems or equipment and the evaluated impact which would require a change in the procedures described in d. below, or which would affect the evaluation of the plant's environmental impact as described in Section 5.4.2.c.

d. Proposed sampling, analysis, calibration and alarm check procedures, as specified in 5.3.1, and any other proposed procedures or changes thereto as determined by the plant superintendent to affect the plant's environmental impact.

e. Investigation of all reported instances of violations of environmental technical specifications. Where investigation indicates, evaluate and formulate recommendations to prevent recurrence.

5.2 Action to be Taken in the Event of Violation of an Environmental Technical Specification.

5.2.1 Follow any remedial action permitted by the technical specification until the specification can be met.

5.2.2 Any environmental technical specification (ETS) violation shall be reported immediately to the Directors of Power Supply and Generation Engineering and promptly reviewed as specified in Section 5.1.

5.2.3 As specified in Section 5.4.2, a separate report for each ETS violation shall be prepared. This report shall include an evaluation of the cause of the occurrence, a record of the corrective action taken, and recommendations for appropriate action to prevent or reduce the probability of a recurrence.

5.2.4 Copies of all such reports shall be submitted to the Assistant General Manager for Power Supply and Generation Engineering for review and approval of any recommendations.

5.2.5 In the event the violation involves a release of radioactive material, copies of the report shall also be submitted to the Chairman, NPPD Safety Review and Audit Board for review and approval of any recommendations.

5.2.6 The Manager of Licensing and Quality Assurance shall report the circumstances of any ETS violations to the AEC as specified in Section 5.4.2.

5.3 Operating Procedures

5.3.1 Detailed written procedures, including applicable check-off lists and instructions shall be prepared, approved as specified in Section 5.3.2 and adhered to for operation of all systems and components involved in carrying out the environmental monitoring program. Procedures shall include sampling, instrument calibration, analysis, and actions to be taken when limits are approached or exceeded.

Calibration frequencies for instruments used in performing the measurements required by the environmental technical specifications shall be included.

Testing frequency of any alarms shall be included. These frequencies shall be determined from experience with similar instruments in similar environments and from manufacturers technical manuals.

5.3.2 All procedures described in 5.3.1 above, and changes thereto, shall be reviewed as specified in Section 5.1 and approved by the Plant Superintendent prior to implementation. Temporary changes to procedures which do not change the intent of the original procedure may be made, provided such changes are approved by two members of the plant management staff. Such changes shall be documented, subsequently reviewed and approved on a timely basis.

5.4 Plant Reporting Requirements

5.4.1 Routine Reports

A semiannual Environmental Monitoring Report covering the previous six months operations shall be submitted within 60 days after January 1 and July 1 of each year. The first such period shall begin with the date of initial criticality. These reports shall include the following:

a. A summary of the results of environmental monitoring programs required by technical specifications including the inventory of chemicals discharged as specified in Section 3.3.

b. An assessment of the observed impacts of plant operation based on the results of environmental monitoring.

c. A brief discussion of any changes in survey procedures of monitoring programs during the report period.

d. A summary of the results of any special environmental studies not required by technical specifications.

e. A brief discussion of any violations of the technical specifications; the date and time, cause, and action taken to prevent recurrence.

f. A summary of the quantities of radioactive effluents released from the plant as outlined in USAEC Regulatory Guide 1.21, with data summarized on a monthly basis following the format of Appendix A thereof.

g. Results for all radiological monitoring samples taken shall be summarized on a quarterly basis following

the format of Table 9. In the event that some results are not available within the 60 day period, the report should be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

h. A brief discussion of any changes as described in Section 5.4.2.c.1 and 2.

i. If statistically significant variations of offsite environmental radionuclide concentrations with time are observed, a comparison of these results with effluent releases shall be provided.

j. Individual samples which show higher than normal levels (25% above background for external dose, or twice background for radionuclide content) should be noted in the reports.

5.4.2 Non-Routine Reports

a. Radiological Reporting Levels

In the event a report level specified below is reached, a report shall be made within the designated time period to the Director of Regulatory Operations, Region IV, with a copy to the Deputy Director for Reactor Projects. It is the clear intent of this section to limit the station related annual dose via the air-milk pathway to 15 mrem or less.

(1) If a measured level of I-131 in the air-milk pathway indicates that the resultant annual dose to the thyroid of an individual from these levels could equal or exceed 60 mrem, the results shall be reported and a plan submitted and implemented within one week to limit conditions so that the annual dose to the thyroid of an individual will not exceed 15 mrem. For example, with an I-131 design objective of 15 mrem/yr to the thyroid of any individual via the air-milk pathway, if individual milk samples show I-131 concentrations of 9.6×10^{-9} μCi/cm^3 (9.6 pCi/l) or greater, the results will be reported along with the plan of action to reduce these levels as discussed above.

TABLE 9

REPORTING OF RADIOACTIVITY IN THE ENVIRONS

Facility________________________ Docket No.____________________________ Reporting Period_________________________

A. Sample Results

Average Quarterly Results 5/

Sample	Location 3/	Frequency and 6/ Type of Samples	Analysis Results 2/ (specify radionuclide or entity)	Remarks 1/
(1) External Radiation				
(2) Filterable Airborne				
a. Particulate Filters				
1)				
2)				
etc.				
b. Charcoal Filters				
1)				
2)				
etc.				
(3) Water 4/				
a.				
b.				
etc.				
(4) Food (Human)				
a.				
b.				
etc.				
(5) Other Media				
a. Vegetation (include pasture and other animal foodstuffs)				
b. Soils				
c. Sediments				
d. Fish				
e. Molluscs				
f. Plankton				
g. Algae				
h. etc.				

1/ Explain any unusual measurements or deviation from sampling schedule.

2/ Use the following units; external radiation, mrem/quarter; filterable airborne, water and milk, μCi/ml; soil, $\mu Ci/m^2$ (specify depth) precipitation, $\mu Ci/m^2$; stream sediments and terrestrial and aquatic vegetation μCi/dry gm; other media, specify units.

3/ Specify location and its distance and direction from the facility, and indicate which is used for background.

4/ Indicate whether precipitation, surface, ground, lake, river, ocean, etc,; specify drinking water.

5/ Use separate table for each quarter.

6/ Type of sample means either grab, continuous, proportional, composite, etc.

(2) If the samples of the air-milk environmental pathway collected over a calendar quarter show total levels of I-131 that could result in accumulated plant related doses to the thyroid of an individual of 7.5 mrem for that quarter, the results shall be reported and a plan submitted and implemented within 30 days to limit conditions so that the annual dose to the thyroid of an individual will not exceed 15 mrem.

If the samples of the air-milk environmental pathway collected over any two calendar quarters show total levels of I-131 that would result in accumulated plant related doses to the thyroid of an individual of 11.3 mrem in those two quarters, the results shall be reported and a plan submitted and implemented within 30 days to limit conditions so that the annual dose to the thyroid of an individual will not exceed 15 mrem.

b. Violations

Notification of violations of an environmental technical specification, including any unplanned release of radioactive material from the site, shall be made within the next working day by telephone or telegraph to the Director of Regulatory Operations, Region IV, followed by a written report within 10 days with a copy to the Deputy Director for Reactor Projects.

The written report and to the extent possible, the preliminary telephone and telegraph report, shall: (a) describe, analyze and evaluate implications, (b) determine the cause of the violation, and (c) indicate the corrective action (including any significant changes made in procedures) taken to preclude repetition of the occurrence and to prevent similar occurrences involving similar components or systems.

The following conditions shall be considered as violations of environmental technical specifications unless otherwise specified by a particular specification.

(1) The occurrence of any condition in violation of an environmental technical specification.

(2) Failure to take appropriate action when a specified report level is reached.

(3) Failure to report in a timely manner, other conditions that indicate a significant environmental impact. Example - a large fish kill at the intake structure.

c. Changes

(1) When a change to the plant (that affects the environmental impact evaluation contained in the Environmental Report and the Environmental Statement) or to the environmental monitoring procedures or equipment is planned, a report of the change shall be submitted to the AEC for information prior to implementation of the change. This is not intended to preclude making changes on short notice that are significant in terms of decreasing adverse environmental impact, etc. However, these changes shall be promptly reported.

(2) Changes or additions to permits and certificates required by Federal, State, local and regional authorities for the protection of the environment shall be reported. When the required changes are submitted to the concerned agency for approval, they shall also be submitted to the Deputy Director, for Reactor Projects, Directorate of Licensing, USAEC, for information. The report shall include an evaluation of the impact of the change.

(3) Request for changes in environmental technical specifications shall be submitted to the Deputy Director of Reactor Projects, Directorate of Licensing, USAEC, for prior review and authorization. The request shall include an evaluation of the impact of the change.

5.5 Records Retention

5.5.1 Records and logs relative to specifications contained in Section 5.0 of the environmental technical specifications shall be retained for five years except as described in 5.5.2.

5.5.2 All records and logs relative to the following areas shall be retained for the life of the plant:

a. Records and drawing changes reflecting plant design modifications made to systems and equipment described in the applicant's Environmental Report.

b. Records of environmental monitoring data.

c. Records of station radiation and contamination surveys.

d. Records of radioactivity in liquid and gaseous wastes released to the environment.

APPENDIX B

Nebraska Public Power District
GENERAL OFFICE
P. O. BOX 499, COLUMBUS, NEBRASKA 68601
TELEPHONE (402) 564-8561

July 13, 1979

Director, Nuclear Reactor Regulation
Attention: Mr. Thomas A. Ippolito, Chief
Operating Reactors Branch No. 3
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington DC 20555

Subject: National Pollutant Discharge Elimination System (NPDES)
Cooper Nuclear Station
NRC Docket No. 50-298, DPR-46

Dear Mr. Ippolito:

Per the Staff's request of July 5, 1979, enclosed please find a copy of the National Pollutant Discharge Elimination System (NPDES) Permit and Section 401 State Certification Letter for Cooper Nuclear Station. The enclosed are also pertinent to, and referenced in, our May 25, 1979 submittal of proposed Radiological Effluent Technical Specifications.

Should you have any questions or require additional information, please contact me.

Sincerely,

Jay M. Pilant

Jay M. Pilant
Director of Licensing
and Quality Assurance

JDW/cmk

Enclosure

7907200260

Permit No. NE 0001244
Application No. 2SB OXT 2-723

DEPARTMENT OF ENVIRONMENTAL CONTROL
AUTHORIZATION TO DISCHARGE UNDER THE STATE OF NEBRASKA
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Federal water Pollution Control Act, as amended (33 U.S.C. 1251 et. seg), the Nebraska Environmental Protection Act (Secs. 81-1505(3)(4)(5)(6) & (7), 81-1504(15)(25), 81-1510(2), R.R.S. 1943), and the Rules and Regulations promulgated pursuant thereto,

Nebraska Public Power District
Cooper Nuclear Station

is authorized to discharge from a facility located at

NE Quarter, NW Quarter, Section 32, Township 5N, Range 16E, Nemaha County

to receiving waters named

Missouri River

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on December 12, 1975.

This permit and the authorization to discharge shall expire at midnight, December 11, 1980.

Signed this 12th day of December, 1975.

Director

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS - FINAL

During the period beginning December 12, 1975 and lasting through December 11, 1980 the permitee is authorized to discharge from outfall(s) serial number(s) - Pipe 001--Cooling water

Such discharges shall be limited and monitored by the permitee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type
Flow-m^3/Day (MGD)	-	-	-	-	Continuous	recorder or pump records
Temperature	-	-	-	103°F	Continuous	recorder

B-3

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly, grab samples.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Sample taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at point of discharge to the Missouri River.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning December 12, 1975 and lasting through December 11, 1980 the permitee is authorized to discharge from outfall(s) serial number(s) Pipe 002--Roof drain runoff

Such discharges shall be limited and monitored by the permitee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type
Flow-m^3/Day (MGD)	-	-	-	-	Monthly*	Grab
Total Suspended Solids	see formula below		30 mg/l	100 mg/l	Monthly*	Composite**
Oil and Grease	see formula below		15 mg/l	20 mg/l	Monthly*	Composite**
Iron, Total	see formula below		1.0 mg/l	1.0 mg/l	Monthly*	Composite**
Copper, Total	see formula below		1.0 mg/l	1.0 mg/l	Monthly*	Composite**

Total Daily Quantity = lbs/day = 8.34 x total flow in MGD during rainfall period x concentration

* Discharge to be sampled on a monthly basis, not to exceed six (6) samples per year.

** A composite sample for this discharge is defined as a series of four (4) representative grab samples taken during a runoff event.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored on a monthly basis, not to exceed six (6) samples a year, using a series of four (4) grab samples taken during a runoff event.
There shall be no discharge of floating solids or visible foam in other than trace amounts.

Sample taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at point of discharge to the Missouri River.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS - FINAL

During the period beginning December 12, 1975 and lasting through December 11, 1980 the permitee is authorized to discharge from outfall(s) serial number(s) - Pipe 003--Screen wash water, floor drain

Such discharges shall be limited and monitored by the permitee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type
Flow-m^3/Day (MGD)	-	-	-	-	Monthly	pump records

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly, grab samples.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Sample taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at point of discharge to the Missouri River.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning December 12, 1975 and lasting through December 11, 1980 the permitee is authorized to discharge from outfall(s) serial number(s) 004--Water Treatment Sludge Basin

Such discharges shall be limited and monitored by the permitee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type
Flow-m^3/Day (MGD)	-	-	-	-	Quarterly	Grab
Total Suspended Solids	-	-	30mg/l	100mg/l	Quarterly	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored quarterly, grab samples.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Sample taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at point of discharge to the discharge canal.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning December 12, 1975 and lasting through December 11, 1980 the permitee is authorized to discharge from outfall(s) serial number(s) 005--Sewage Treatment Plant

Such discharges shall be limited and monitored by the permitee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type
Flow-m^3/Day (MGD)	-	-	-	-	Monthly	-
Biochemical Oxygen Demand	0.45(1.0)	0.68(1.50)	30mg/l	45mg/l	Monthly	24 hour composite
Total Suspended Solids	0.45(1.0)	0.68(1.50)	30mg/l	45mg/l	Monthly	24 hour composite
Fecal Coliforms	-	-	200/100ml	400/100ml	Monthly	grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly, grab samples.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Sample taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at point of discharge to the discharge canal.

B. SCHEDULE OF COMPLIANCE

1. The permitee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   N/A

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permitee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. REPRESENTATIVE SAMPLING

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. REPORTING

Monitoring results obtained during the previous 3 months shall be sumarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period.

The first report will be submitted for the period ending March 31, 1976-

Subsequent reports will be for the periods ending June 30, September 30, December 31 and March 31.
Properly filled in and signed Monitoring Reports will be mailed to the following address:

Nebraska Department of Environmental Control
WPC-Permits and Enforcements Section
P.O. Box 94653 State House Station
Lincoln, Nebraska 68509

3. TEST PROCEDURES

Test procedures for the analysis of pollutants shall conform to Guidelines for Test Procedures For The Analysis of Pollutants Under the National Pollutant Discharge Elimination System (40 CFR 136). If those Guidelines do not specify test procedures for any pollutant required to be monitored by this permit and until such guidelines are promulgated, sampling and analytical methods used to meet the monitoring requirements specified in this permit shall, unless otherwise specified by the Director conform to the lastest edition of the following references:

Standard Methods for the Examination of Water and Wastewaters, 13th Edition, 1971, American Public Health Association, New York, New York 10019.

A.S.T.M. Standards, Part 23, Water; Atmospheric Analysis, 1972, American Society for Testing and Materials, Philadelphia, Pennsylvania 19103.

Methods for Chemical Analysis of Water and Wastes, April 1972, Environmnetal Protection Agency Water Quality Office, Analytical Quality Control Laboratory, NERC, Cincinnati, Ohio 45268.

4. RECORDING OF RESULTS

For each measurement or sample taken pursuant to the requirements of this permit, the permitee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

5. ADDITIONAL MONITORING BY PERMITEE

If the permitee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

6. RECORDS RETENTION

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, with such period of retention being extended during the course of any unresolved litigation regarding the discharge of pollutants by the permitee or when requested by the Director.

A. MANAGEMENT REQUIREMENTS

1. *CHANGE IN DISCHARGE*

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by the permitee 60 days prior to the expansion, increases, or modifications, by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. *NONCOMPLIANCE NOTIFICATION*

If, for any reason, the permitee does not comply with or will be unable to comply with any daily maximum or weekly average effluent limitation specified in this permit, the permitee shall provide the Department of Environmental Control with the following information, in writing, within five(5) days of becoming aware of such conditions:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. *FACILITY OPERATION AND QUALITY CONTROL*

All waste collection, control, treatment and disposal facilities shall be operated in a manner consistent with the following:

a. At all times, all facilities shall be operated as efficiently as possible and in a manner which will minimize upsets and discharges of excessive pollutants.

b. The permitee shall provide an adequate operating staff which is duly qualified to carry out the operation, maintenance and testing functions required to insure compliance with the conditions of this permit.

c. Maintence of treatment facilities that results in degradation of effluent quality shall be scheduled during non-critical water quality periods and shall be carried out in a manner approved by the permitting authority.

4. *ADVERSE IMPACT*

The permitee shall take all reasonable steps to minimize any adverse impact to waters of the State resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. *BYPASSING*

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permitee shall promptly notify the Department of Environmental Control in writing of each such diversion or bypass.

6. *REMOVED SUBSTANCES*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering any waters of the State.

7. *POWER FAILURES*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permitee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

   or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *RIGHT OF ENTRY*

The permitee shall allow the Director of the Department of Environmental Control or his authorized representatives, upon the presentation of credentials:

a. To enter upon the permitee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *TRANSFER OF OWNERSHIP OR CONTROL*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permitee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department of Environmental Control no later than 30 days after transfer of control or ownership.

3. *AVAILABILITY OF REPORTS*

All NPDES forms and any public comment upon those forms shall be available to the public for inspection and copying, except any NPDES form information (except effluent data) or comment which is classified as confidential pursuant with the Nebraska Rules and Regulations Pertaining to the Issuance of Permits under the National Pollutant Discharge Elimination System.

4. *SIGNATURES*

All NPDES Forms, applications or correspondence submitted to the Department as well as each submitted Discharge Monitoring Report shall be signed as follows:

a. If submitted by a corporation, by a principal executive officer of at least the level of vice president, or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which the discharge described in the Discharge Monitoring Report originates;

b. If submitted by a partnership, by a general partner;

c. If submitted by a sole proprietor, by the proprietor;

d. If submitted by a municipality, State agency, or other public entity, by a principal executive officer, ranking elected official, commanding officer, or other duly authorized employee.

Any change in signatories after submission of any NPDES form, application, correspondence or discharge monitoring report and any transfer of a permit after issuance, shall be brought to the attention of the Department in writing within 30 days after the change of transfer.

5. *PERMIT MODIFICATION*

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

d. Upon request by the permitee, provided such request does not create a violation of any existing applicable requirements, standards, laws, or rules and regulations.

6. *TOXIC POLLUTANTS*

Notwithstanding Part II, B-5 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established and adopted by the Council under Section 81-1505(6) of the State Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permitee so notified.

7. *CIVIL AND CRIMINAL LIABILITY*

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permitee from civil or criminal penalties for noncompliance. Whether or not such noncompliance is due to factors beyond his control, such as equipment breakdown, electric power failure, accident, or natural disaster.

8. *OIL AND HAZARDOUS SUBSTANCE LIABILITY*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permitee from any responsibilities, liabilities, or penalties to which the permitee is or may be subject under Section 311 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

9. *PROPERTY RIGHTS*

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State, or local laws or regulations.

10. *OTHER RULES AND REGULATIONS LIABILITY*

The issuance of this permit in no way relieves the obligation of the permitee to comply with any and all other Departmental Rules and Regulations.

11. *ONSHORE - OFFSHORE CONSTRUCTION*

This permit does not authorize or approve the construction of any onshore or offshore physical structures or facilities or the undertaking of any work in any navigable waters.

12. *SEVERABILITY*

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

-Discharge 001-

Thermal plume monitoring shall be conducted by the permittee during 100% power production periods which are realized in conjunction with summer low river flow and winter low river flow conditions. The permittee shall determine the 2.8 C (5° F) contour line above ambient stream temperature and isotherms at 1.1° C intervals within this contour line. The area within the contours shall be determined, the percentage of cross-sectional area and volume of flow that the discharge comprises with respect to the receiving stream shall also be determined. These plume studies shall be conducted when possible during the most critical temperature conditions in the stream, i.e., maximum summer ambient river temperature during low river flow conditions.

Intake monitoring data shall be submitted on a quarterly basis, the first monitoring report will be for the period ending March 31, 1976.

J. JAMES EXON
GOVERNOR

STATE of NEBRASKA

J. L. HIGGINS
DIRECTOR

DEPARTMENT OF ENVIRONMENTAL CONTROL

BOX 94653, STATE HOUSE STATION
LINCOLN, NEBRASKA 68509
(402) 471-2186

April 16, 1973

Nebraska Public Power District
P.O. Box 499
Columbus, Nebraska 68601

Attention Eric N. Sloth, Ph. D.
Environmental Manager

Dear Dr. Sloth:

Reference is made to your letter of April 6, 1973, requesting State Certification as required by Section 401 of The Federal Water Pollution Control Act Amendments of 1972, (P.L. 92-500), in regard to Cooper Nuclear Station.

As provided in Section 401, certification is required relating to compliance with the applicable provisions of Sections 301, 302, 306, and 307 of P.L. 92-500.

Pursuant to Section 401(a) of the Act, we certify that at the present time, there is not an applicable effluent limitation or other limitation under Sections 301(b) and 302, and there is not an applicable standard under Sections 306 and 307 of the Act.

Very truly yours,

J. L. Higgins, Director

RB/gdm

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U.S. NUCLEAR REGULATORY COMMISSION

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Aquatic Impacts from Operation of Three Midwestern Nuclear Power Stations
Cooper Nuclear Station
Environmental Appraisal Report

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)
James R. Brice

5. DATE REPORT COMPLETED
MONTH August YEAR 1981

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Environmental Science and Engineering, Inc.
P.O. Box ESE
Gainesville, Florida 32601

DATE REPORT ISSUED
MONTH October YEAR 1981

6. (Leave blank)

8. (Leave blank)

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Division of Engineering
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.
FIN B6854

13. TYPE OF REPORT

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15. SUPPLEMENTARY NOTES

14. (Leave blank)

16. ABSTRACT (200 words or less)

Cooper Nuclear Station is located on the Nebraska side of the Missouri River in Nemaha County. The station utilizes a boiling water reactor and steam turbine generator to produce 778 MW (net) of electrical power. The cooling system is a once-through design that withdraws water from, and discharges to, the Missouri River.

No significant adverse impacts to the biota of the Missouri River from the Cooper Nuclear Station discharge were detected. Localized effects in the vicinity of the discharge have been observed. These include changes in the diversity and productivity of phytoplankton, periphyton, and benthic invertebrates at certain times of the year.

The station appears to entrain large numbers of catostomid larvae, but this loss is not reflected in the available commercial fisheries statistics. Large numbers of gizzard shad and freshwater drum are impinged annually by Cooper Nuclear Station, but neither of these species seem to be adversely affected. Bigmouth buffalo populations could potentially suffer losses, but as was the case with the other catostomids, commercial catches of bigmouth buffalo did not seem to be affected by station operation.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Missouri River, Nuclear Plant, Impingement, Entrainment, Thermal Effluent

17b. IDENTIFIERS/OPEN-ENDED TERMS

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