Final

environmental statement

related to operation of

QUAD-CITIES NUCLEAR POWER STATION UNITS 1 & 2

COMMONWEALTH EDISON COMPANY
AND THE IOWA-ILLINOIS GAS AND ELECTRIC COMPANY

DOCKET NOS. 50-254 AND 50-265

ATOMIC ENERGY COMMISSION
UNITED STATES OF AMERICA

Jennifer Davis

SEPTEMBER 1972

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Final Environmental Statement was prepared by the U. S. Atomic Energy Commission, Directorate of Licensing.

1. This action is administrative.

2. This statement is submitted in relation to the proposed continuation of Facility Operating Licenses Nos. DPR-29 and DPR-30 to the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company for the operation of the Quad-Cities Nuclear Power Station, Units 1 and 2, located in the State of Illinois, County of Rock Island near the town of Cordova (Docket Nos. 50-254, 50-265). The station will employ two Boiling Water Reactors to produce 5022 megawatts thermal (MWt) or 1618 megawatts net electrical (MWe). The exhaust steam will be cooled by once-through condenser cooling with a diffuser-pipe discharge until a spray-canal cooling system is completed on or before May 1, 1975.

3. Summary of environmental impact and adverse effects:

   a. Reassignment of about 560 acres from agricultural and woodland use to industrial use.

   b. Construction of about 125 miles of transmission lines through mostly agricultural lands.

   c. Siltation of the river and dislocation or loss of benthic organisms caused by construction of the diffuser-pipe and dislocation of small animals caused by the construction of the spray-canal.

   d. Heating of 2270 cfs of Mississippi River water about 23°F above ambient until May 1975, thereafter spray-canal heating of about 50 cfs and evaporation of about 50 cfs. The heated water from the diffuser-pipe will cause a small amount of evaporation and will have a small effect on the aquatic biota which will be recoverable.

   e. Discharge of small concentrations of chemicals that are expected to produce no deleterious effects on the environment.

   f. Creation or enhancement of steam fog during operation of the spray-canal during some periods of the year.

g. After modifications to both the liquid and gaseous radwaste system there will be a discharge of small quantities of radioactive liquid and gaseous wastes to the environment, which will have a minimal effect. Prior to the modification the levels of radioactive waste will be somewhat higher but still in accordance with the limitations set forth in 10 CFR Part 20 and 10 CFR Part 50.

h. Creation of a low risk of accidental radiation exposure to the residents in the vicinity of the site.

i. Creation of a low level of radiation exposure due to transport of radioactive materials.

4. Principal alternatives considered:

   a. The use of fossil fuels

   b. The purchase of power

   c. Adoption of closed cycle cooling with cooling towers, spray ponds and cooling lake.

   d. Additional radioactive waste treatment equipment.

   e. Delay of operation of the station.

   f. Abandonment of the station.

5. Comments from the following Federal and State Agencies have been received on the Draft Environmental Statement:

   Department of Transportation
   Department of Commerce
   Department of the Army, Corps of Engineers
   Department of Health, Education and Welfare
   Federal Power Commission
   Department of the Interior
   Department of Agriculture
   Environmental Protection Agency
   Illinois Pollution Control Board, Mr. Dumelle
   Illinois Pollution Control Board, Mr. Kissel
   Illinois Environmental Protection Agency
   University of Wisconsin, Professor Nees

These comments were forwarded to the applicants for response. Copies of these comments are attached as Appendix A.

An addendum to the Draft Environmental Statement concerning the spray-canal cooling system was issued for comment on June 9, 1972. Comments on this addendum have been received from the following Agencies:

Federal Power Commission
Department of Transportation
Department of the Army, Corps of Engineers
Illinois Department of Conservation
Department of Health Education and Welfare
Environmental Protection Agency
Department of Agriculture
Department of the Interior

These comments were forwarded to the applicants for response. Copies of these comments are attached as Appendix B.

7. This statement was made available to the Council on Environmental Quality in September 1972.

8. On the basis of the analysis and evaluation set forth in this statement, and after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, it is concluded that the action called for is the continuation of Facility Operating Licenses Nos. DPR-29 and DPR-30 for the Quad-Cities Nuclear Power Station Units 1 and 2, subject to the following conditions for protection of the environment:

   a. The applicants will define an environmental (chemical, biological, and thermal) monitoring program considered by the regulatory staff to be adequate to determine any changes which may occur in land and water ecosystems as a result of station operation.

   b. The applicants will define a radiological monitoring program considered by the regulatory staff to be adequate to determine any radiological effects on the environment from operation of the station.

c. The applicants will provide semi-annual reports describing the results of the environmental monitoring program. This report will include conclusions derived from the data and a definitive compendium of any environmental effects and a discussion of the means to be taken to assist natural recovery.

d. The applicants will propose appropriate modifications to the Technical Specifications prior to operation of the spray-canal cooling system.

QUAD-CITIES

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FOREWORD

This Final Environmental Statement (statement) associated with the proposed operation of the Quad-Cities Nuclear Power Station Units 1 and 2 (station) (Docket Nos. 50-254 and 50-265) by the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company (the applicants) has been prepared by the U. S. Atomic Energy Commission's (AEC) regulatory staff (staff) pursuant to the AEC's regulations, Section 10 Code of Federal Regulations Part 50 (10 CFR Part 50), Appendix D, implementing the National Environmental Policy Act of 1969 (NEPA).

By application dated September 3, 1968, and revised June 16, 1970, and amendments thereto (the application), the applicants applied for the necessary licenses to operate two nuclear power reactors. The application is available for public inspection at the AEC's Public Document Room, 1717 H Street, N. W., Washington, D. C., and has been forwarded to appropriate Federal, State and local officials. Construction of the station was authorized by the Commission upon the issuance of provisional construction permits on February 15, 1967. The application for an operating license, which would authorize the operation of Units 1 and 2 of the station at 2,511 megawatts thermal (MWt) each, is presently pending before the Commission.

A Draft Detailed Statement of the Environmental Considerations was sent to the appropriate federal agencies on January 14, 1971. Replies were received from the Departments of Commerce, Interior, Defense and Transportation, the Environmental Protection Agency (EPA), and the Federal Power Commission (FPC). It was also sent to the States of Illinois and Iowa. No comments were received from either state.

On March 16, 1971, a notice of the proposed issuance of these operating licenses was published in the Federal Register (36 FR 5008). The notice offered an opportunity for a hearing, but there were no requests for a hearing.

A Final Detailed Statement of the Environmental Considerations was issued July 2, 1971, with comments from the above agencies and responses from the applicants attached as appendices. On July 12, 1971, notice of the availability of the Final Detailed Statement on Environmental Considerations for Quad-Cities Station Units 1 and 2, prepared by the AEC Division of Radiological and Environmental Protection, was published in the Federal Register (36 FR 13699).

The detailed statement considered the environmental aspects associated with full-power operation of the station. It was prepared in accordance with the then current requirements of Appendix D to 10 CFR Part 50 published on December 4, 1970, which implemented the National Environmental Policy Act of 1969 (NEPA).

On August 25, 1971, the staff completed its review of the application and issued its Safety Evaluation in which it concluded that there was reasonable assurance that Units 1 and 2 of the station could each be operated up to full power (2,511 MWt) without endangering the health and safety of the public. However, on September 9, 1971, the Commission revised Appendix D to 10 CFR Part 50 to comply with the decision of the Court of Appeals for the District of Columbia circuit in Calvert Cliffs Coordinating Committee et al. vs. the Atomic Energy Commission et al. The revised NEPA regulations provided *inter alia* for a supplemental NEPA review for facilities such as the Quad-Cities Units. This new final statement represents the supplemental review, which is more comprehensive and in greater depth than the previous version, pursuant to 10 CFR Part 50 Appendix D as revised September 9, 1971.

Appendix D provides a procedure in Section D.3 for issuance of an interim operating license authorizing the loading of fuel in the reactor core and limited operation of the facility. This procedure may be applied to applications for an operating license for a nuclear facility for which the Commission published a notice of opportunity for hearing prior to October 31, 1971, and no hearing was requested. The limited license may be issued by the Commission, pending the completion of an ongoing NEPA environmental review of a full-power license application, upon a showing that such licensing action will not have a significant adverse impact on the quality of the environment, or after considering and balancing the factors described in Section D.2 of Appendix D, and upon the Commission's making appropriate findings on the matters specified in 10 CFR Part 50.57(a).

On July 16, 1971,[1] the applicants requested that the Commission issue an operating license for Unit 1 authorizing the loading of fuel in the reactor core and other activities which require operation of Unit 1 not in excess of one percent (25 MWt) of full power. In accordance with the provisions of Section D.3 of Appendix D of 10 CFR Part 50, the low-power license requested by the applicants was issued on October 1, 1971. The basis for that action was set forth in a public document entitled, "Discussion and Findings by the Division of Reactor Licensing, U.S. Atomic Energy Commission, Pursuant to Appendix D of

10 CFR Part 50, Supporting the Issuance of an Operating License to Commonwealth Edison Company and Iowa-Illinois Gas and Electric Company Authorizing the Loading of Fuel and Operating not in Excess of 25 MWt, Quad-Cities Station Unit 1, Docket No. 50-254."

On October 12, 1971,[2] the applicants requested the Commission, in accordance with the provisions of Section D.3 of Appendix D, to authorize interim limited power operation of Units 1 and 2 during the ongoing supplemental NEPA environmental review of their application for operation of both units at full power. Specifically, the applicants requested the Commission to issue an amendment to Operating License DPR-29 for Unit 1 and to issue an operating license for Unit 2 authorizing

(a) fuel loading in Unit 2,

(b) conduct of all necessary testing of each unit separately up to and including its full rated power, and

(c) operation of the two units up to an aggregate level of 809 megawatts net electrical (equivalent to 2,511 MWt) until March 15, 1972.

On November 18, 1971,[3] the request was amended to extend the period of limited operation until such time as a full-power operating license is received. The applicants stated that the station would operate during the testing period at an average of less than 20 percent of full capacity (1,004 MWt of the station's full capacity of 5,022 MWt). The applicants submitted further that their request meets either of the two standards established by Section D.3 (summarized above).

On December 13, 1971, <u>The Isaac Walton League of America et al</u>. vs. <u>James Schlesinger et al</u>.; <u>People of the State of Illinois et al</u>. vs. <u>U. S. Atomic Energy Commission et al</u>.; Civil Action Nos. 2207-71 and 2208-71, the U. S. District Court for the District of Columbia issued a preliminary injunction prohibiting the Commission, pending final disposition of the suit, from issuing "any partial operating license pursuant to Section D.3 of Appendix D to 10 CFR Part 50 for the Quad-Cities Nuclear Power Station" prior to the completion of procedures specified in Section 102(2)(c) of NEPA (requiring the preparation and distribution by the AEC of a NEPA envitonmental statement).

An extension to the Unit 2 construction permit was granted on January 21, 1972, to allow for environmental delays. On January 24, 1972, the AEC completed an evaluation of the environmental impact of fuel loading, testing and operation up to 20 percent of full power for the Quad-Cities Units. The resultant report[4] concluded that these activities would give rise to only a minimal impact on the environment and would not foreclose subsequent adoption of alternatives and that there would be an adverse effect upon the public interest as a result of delay in facility operation. The evaluation recommended that, "authorization of interim operation at a power level up to 20 percent (502 MWt) during the period ending June 1, 1972, should be granted."

On March 6, 1972, the Draft Detailed Statement on Environmental Considerations was issued according to 10 CFR Part 50 Appendix D as revised September 9, 1972. It was announced by a notice in the Federal Register on March 9, 1972 (37 FR 5073) which invited comments from any interested persons.

Subsequent to the issuance of the "Discussion and Conclusions by the U. S. Atomic Energy Commission, Divisions of Radiological and Environmental Protection and Reactor Licensing Pursuant to Appendix D of 10 CFR Part 50 Supporting the Issuance of Licenses to Commonwealth Edison Company and Iowa-Illinois Gas and Electric Company Authorizing 20 Percent Operation of the Quad-Cities Station Units 1 and 2 Docket Nos. 50-254 and 50-265" issued January 24, 1972, the Commonwealth Edison Company provided the Commission copies of an agreement reached between the Commonwealth Edison Company and the plaintiffs in the above litigation pending in the U. S. District Court for the District of Columbia relating to the operation of the Quad-Cities Station Units 1 and 2. The agreement set forth certain modifications of the condenser cooling water system and plans for operation of Quad-Cities Units 1 and 2. The AEC staff evaluated the contents of the agreement and concluded that the staff's Discussion and Conclusions, dated January 24, 1972, were unmodified by the contents of the agreement. The January 24, 1972, Discussion and Conclusions dealt only with the operation of Quad-Cities Station Units 1 and 2 at 20 percent of station power until June 1, 1972. The staff concluded that operation of the station at 20 percent of power for this period of time would not foreclose any of the alternatives for the protection of the environment.

Based on the January 24, 1972, Discussion and Conclusions and the March 31, 1972, Supplement to the Discussion and Conclusions, Facility Operating License Number DPR-29 was amended and Facility Operating License Number DPR-30 was issued to permit Units 1 and 2 of the station to operate up to 20 percent of full power each from April 24, 1972, until June 1, 1972.

On April 12, 1972 the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company (applicants), in a letter from Mr. Bryon Lee, Jr. to Dr. Peter A. Morris, requested, pursuant to Paragraph D(3) of Appendix D of 10 Code of Federal Regulations Part 50, authority to complete all necessary testing of each unit up to its full power rating, but to do so without at any time operating the two units at an aggregate power level in excess of one-half of their combined capacity. The applicants also requested "....authorization to operate the station after testing is completed until September 15, 1972 (the anticipated end of the summer peak electrical load period) in the following manner:

a. Upon completion of the power test program, to operate at power levels up to 200 MWe for each unit. This minimum level is required to avoid damage to the turbine from operation for extended periods at levels below 200 MWe;

b. To operate above 200 MWe, but not more than 500 MWe for each unit, only on those days in which, in the judgment of the system load dispatchers, total demand is likely to exceed available capacity unless the Quad-Cities Station capacity is greater than 400 MWe even if all available emergency power were purchased. Such operation can be expected on days when the air temperature exceeds 90°F or unusual outages are experienced; and

c. To operate at power levels above 500 MWe only when in the judgment of the system load dispatchers, capacity in excess of that amount will be required to meet demands. Operation above 500 MWe is not expected to occur for more than eight hours in any 24-hour period."

The interim licensing procedure set forth in section D.3, discussed previously herein, provides however, that operation beyond 20 percent (20%) of full power will not be authorized except in emergency situations or other situations where the public interest so requires. Any license so issued will be without prejudice to subsequent licensing action which may be taken by the Commission with regard to the environmental aspects of the facility, and any license issued will be conditioned to that effect.

On April 24, 1972, the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company submitted Supplement No. 5 to the Environmental Report for the Quad-Cities Nuclear Power Station Units 1 and 2. In Supplement No. 5, the applicants describe proposed changes to the

Station condenser cooling water system which came about as the result of an agreement between applicants and the plaintiffs in the above litigation in the U. S. District Court for the District of Columbia.

On April 25, the Illinois Pollution Control Board issued an Opinion and Supplemental Order of the Board. This document modified the permit, issued by the State of Illinois on November 15, 1971, to operate the Station. This Opinion and Supplemental Order permitted a variation from the State of Illinois Mississippi River temperature standards R 70-16 until the diffuser discharge is installed but no later than August 15, 1972.

On May 12, 1972, Facility Operating Licenses Nos. DPR-29 and DPR-30 were amended to permit limited operation of each unit at maximum power of 2260 MWt (90 percent of rated power). On August 15, 1972, these licenses were amended to permit steady state operation at 2260 MWt (90 percent of rated power). These licenses will be amended further as indicated by the full NEPA review when it is completed.

On June 9, 1972, Addendum I to the Draft Detailed Statement on Environmental Considerations dated March 6, 1972, was issued to update portions of that Draft Statement necessitated by the submission of Supplement No. 5 of the applicants' Environmental Report. The Addendum was announced by a notice in the Federal Register on June 9, 1972 (37 FR 11598), which invited comments from any interested persons.

This Final Environmental Statement is based upon data obtained by the staff from the applicants and other sources, including State and Federal agencies, and the evaluation of the data by the staff. Independent calculations were made and used as a basis for the staff's assessment of environmental impact. In addition, some of the information was gained from a visit to the station and surrounding areas on August 18 and 19, 1971, and April 6 and 7, 1972, by several regulatory staff members and AEC consultants.

The applicants' Environmental Report and Supplements, Preliminary and Final Safety Analysis Reports, and the verbatim record with exhibits from the Illinois Pollution Control Board hearings on the station, May 25 - June 9, 1971, and the Iowa Water Pollution Control Commission Hearings, November 2, 1971 and December 29, 1971, were the major documents used for the preparation of this statement. The first set of documents is available in the Commission's Public Document Room, 1717 H Street, Washington, D. C. The Illinois Pollution Control

Board documents are available at its office, 309 W. Washington Street, Chicago, Illinois. The Iowa Water Pollution Control Commission documents are available at its offices at the State Office Building, Des Moines, Iowa 50319. Section XI provides a detailed listing of the documents used in this review.

This Final Environmental Statement also takes into account the Agency comments on the Draft Environmental Statement, Addendum I to the Draft Environmental Statement and the applicants' response to these comments.

As a part of its safety evaluation leading to the issuance of construction permits and operating licenses, the Commission staff makes a detailed evaluation of (1) the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal operating and potential accident conditions, (2) the adequacy of the applicant's effluent and environmental monitoring programs, and (3) the potential radiation exposure that might be received by station workers and members of the public. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated dose to the public are repeated here. The comments that have been received from other Federal and State agencies in respect to overall safety evaluation are not elaborated on here.

The applicant is required to comply with section 21(b) of the Federal Water Pollution Control Act, as amended by the Water Quality Improvement Act of 1970.

M. Grotenhuis is the AEC Environmental Project Manager for this statement (telephone 301-973-7588).

I. INTRODUCTION

The Quad-Cities Nuclear Power Station Units 1 and 2 is a facility of the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company. The station is located in Rock Island County on the east bank of the Mississippi River, about 3 miles north of Cordova, Illinois, and about 20 miles northeast of the Quad-Cities-Bettendorf area. The Quad-Cities are Davenport, Iowa, and Rock Island, Moline, and East Moline, Illinois. Bettendorf, Iowa, is an adjacent city to the northeast of the Quad-Cities. The approximately 560-acre site is flat, with a grade level about 9 ft above maximum recorded flood stage. The surrounding land areas are largely in agricultural use, with an industrial park directly north of the station (see figure 6). There are industrial concentrations in the city of Clinton, Iowa, 7 miles northeast of the station, and in the Quad-Cities-Bettendorf area.

A. SITE SELECTION

The site for the station was selected for the following reasons:

1. The site is convenient for the joint utility operations of the applicants' western area. The site is in the Iowa-Illinois Gas and Electric Company's operating territory and is near to the western part of Commonwealth Edison Company's territory. The latter has need for generating capacity in that area.

2. Cordova, Illinois, was attempting to expand the industrial area along the Mississippi River north of the town.

3. The Mississippi River is adjacent to the site and has an adequately large flow to absorb the heat.

The applicants state[1]

> "Nuclear fuel was chosen as opposed to fossil fuel because it was and is still believed that nuclear fuel will be the more economical of the two fuels for future use. Basically, fossil fuel technology is well developed and no major breakthroughs are expected to occur in the near future that would drastically lower its cost. On the other hand, nuclear technology is still an infant technology and should achieve innovations that reduce or maintain fuel costs at present levels. Moreover, we believe that in the long run a conversion to nuclear power is one of the best solutions to help reduce air pollution."

The site is relatively remote from population. Thirty-seven residences are reported within a zone one mile north and south of the station's fences along the Mississippi River. Within a five-mile radius of the station, the population density is 75 people per square mile, representing a total population of 5,845 within this zone.

The particular area in which the station is located is a relatively unused section along the Mississippi River. The land in the immediate area appears to be somewhat lower in agricultural productivity than much of the lands in the general region. Also, the land directly north of the station is already committed to an industrial site, so the station is consistent with a major neighbor.

B. APPLICATIONS AND APPROVALS

The following approvals, relating to environmental matters, have been obtained by the applicants from various Federal, State and local agencies.

Federal

1. Corps of Engineers - Permit for transmission lines to cross the Mississippi River.

2. Corps of Engineers - Permit for construction and maintenance of diffuser-pipe.

3. Federal Aviation Administration - Permit for construction of transmission lines.

State of Illinois

1. Sanitary Water Board - Construction and operation of liquid and solid radioactive waste, radioactive waste disposal systems, lift station, and sewage treatment plant.

2. Sanitary Water Board - Permit to discharge condenser cooling water.

3. Department of Highways - Permit for transmission lines to cross highways.

4. Department of Public Works & Buildings, Division of Waterways - Dredging and maintenance of intake and discharge flumes, construction of temporary dock and pier, installation of diffuser-pipe system.

5. Department of Aeronautics - Construction of meteorological survey tower and gaseous radwaste chimney.

6. Commerce Commission - Certificate of Public Convenience and Necessity.

7. Department of Mines and Minerals, Division of Oil and Gas - Drilling of water wells.

8. Air Pollution Control Board - Permit to install and operate heating boiler.

9. Division of Water Ways - Permit to cross Mississippi River.

10. Pollution Control Board - Operating permit.

11. Department of Public Health - Certificate of registration Illinois radiation installation.

State of Iowa

1. Iowa Water Pollution Control Commission - Permit to construct the diffuser-pipe system.

2. Iowa Water Pollution Control Commission - Permit to operate the diffuser-pipe.

3. Iowa Highway Commission - Permit for transmission lines to cross highways.

4. Iowa State Commerce Commission - Franchise to build transmission lines.

5. Iowa Conservation Commission - Construction Permit for the Diffuser-pipe.

6. Iowa Natural Resources Council - Construction Permit for the Diffuser-pipe.

Local Agencies

1. Rock Island Zoning and Building Department - Construction permits and permits for demolition of buildings.

2. Commissioner of Cordova Townships Roads - Permission to close road.

Atomic Energy Commission Hearings on the Construction Permit

Federal Building, Rock Island, Illinois, January 24, 1967.

Illinois Pollution Control Board Hearings

Chicago, Illinois. Hearing 71-20, May 24 to June 9, 1971
Applicants Brief and Attorney General Brief (Aug. 5, 1971)
Applicants' Reply Brief (Sept. 8, 1971)

Iowa Water Pollution Control Commission

Des Moines, Iowa (November 11, 1971)(December 29, 1971)

Iowa Conservation Commission

Des Moines, Iowa, April 4, 1972

Agencies Consulted by the Applicants

Illinois Department of Natural Resources
Department of Interior, Fish and Wildlife

II. THE SITE

A. GENERAL

The site for the station is on the Illinois side of the Mississippi River about 58 miles south of the northern boundary of the State of Illinois and opposite the mouth of the Wapsipinicon River. The Mississippi River flow is controlled below flood stage throughout its length by a series of locks and dams, so that its channels and levels are available for transportion. The river is a source of municipal water; it is also used for commercial and sport fishing and for recreational boating. There is a major population center at the Quad-Cities-Bettendorf area which is within a 25-mile radius of the station. At the river shore in the vicinity of the station are areas devoted to residences, industrial plants, a wildlife refuge, and recreational sites. Major land areas in this vicinity are under agricultural usage, including vegetable growing and livestock. The site extends about 0.83 mile along the river and 1.0 mile inland with an irregular boundary.

In order to ascertain the suitability of this site for use as a nuclear power plant, reviews have been made of the geology, seismology, meteorology, hydrology, demography, and of land and water usage by the applicants[1,2,3,4] and the staff. A brief review is presented here.

B. LOCATION

The Quad-Cities Station is located in Rock Island County on the east bank of the Mississippi River, about three miles north of Cordova, Illinois, about 20 miles northeast of the Quad-Cities-Bettendorf area, and about seven miles southwest of Clinton, Iowa. The Quad-Cities are Davenport, Iowa, and Rock Island, Moline and East Moline, Illinois. Bettendorf, Iowa, is a city adjacent to and northeast of the Quad-Cities.

The approximately 560 acre site* is flat, with a grade level about 9 feet above the maximum recorded flood stage. Surrounding land areas are largely in agricultural use, with an industrial park directly north of the station. There are industrial concentrations in the Clinton, Iowa, and Quad-Cities-Bettendorf areas.

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* The site was expanded from its original acreage of about 400 to accommodate the spray-canal system to be installed, for Unit 1[18]. Expansion of the spray-canal[25] to include Unit 2 did not require a further commitment of land.

The geographical location of the plant with respect to the upper Mississippi River system is shown on Figure 1. Moline, Illinois, one of the Quad-Cities, is located on the map, and the station location is indicated south of Clinton, Iowa, on the Illinois side of the river. The location of the site with respect to the locks and dams of the Mississippi River is shown in Figure 2; sections of river between dams are referred to as "pools" which are numbered consecutively southward from St. Anthony Falls, Minnesota. Distances along the river are designated as "river miles" measured northward from the confluence of the Ohio River. The station is located about midway in Pool 14, at river mile 506.5 at standard river elevation 572.0 ft., about 16 miles below Dam 13 and about 13 miles from Dam 14.

The location of the station in the region of the 50-mile radius is shown in Figure 3, showing the principal communities and roads. The site for the station is in Rock Island County, Illinois, in parts of Section 7, 8, 17, and 18.

The general site plan in the immediate plant area is shown in Figures 4a and 4b. The primary area containing the operating facilities, including switchyards, is about 100 acres of the approximately 560 acre property area west of Illinois Route 84. About 100 acres are forested. Some of these trees will be removed for the spray canal construction.

C. REGIONAL DEMOGRAPHY AND LAND USE

The region is predominantly agricultural with industrial concentrations along the river, especially in the Clinton, Iowa, area to the northeast and in the Quad-Cities-Bettendorf area to the southwest. The nearest village is Cordova, about three miles to the south, with a 1970 population of 589. The village of Albany, approximately four miles north, has a population of about 800. The nearest city is Clinton, Iowa, located in a zone 5 to 10 miles northeast and having a 1970 population of 43,419. The largest populated area is the group of contiguous cities: Rock Island, Moline and East Moline, Illinois, and Davenport and Bettendorf, Iowa. The 1970 population of this five-city area was 234,725. The boundaries of these cities lie in a zone 13 to 25 miles from the station. The population densities within a 50-mile radius of the station are shown in Figures 5a, 5b, and 5c. The projected population for Clinton in the year 2000 is 46,700 and for the Quad-Cities-Bettendorf area, 460,700.

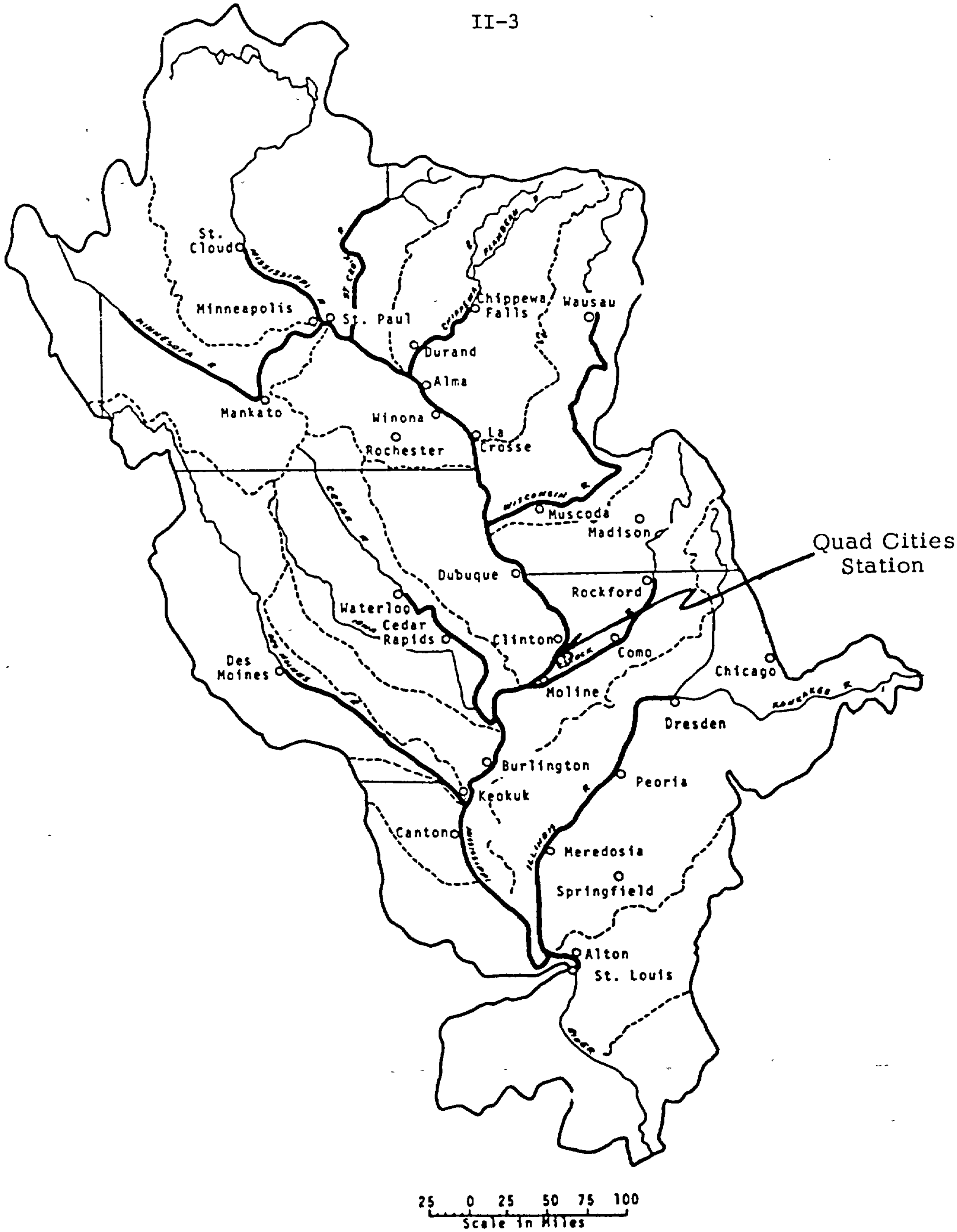


FIGURE 1. Upper Mississippi River Basin

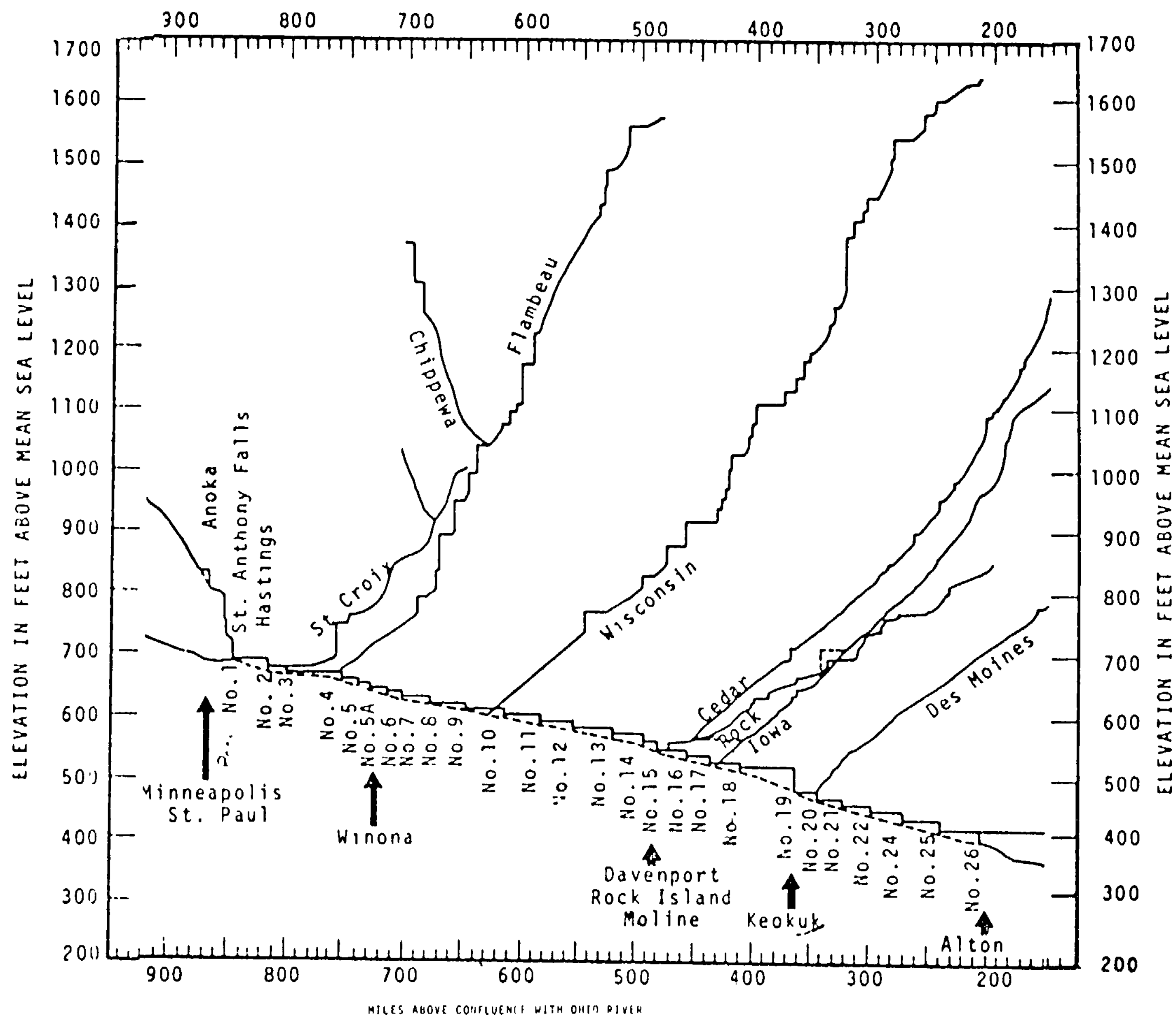


FIGURE 2. Upper Mississippi River Profiles; Main Stem and Major Tributaries

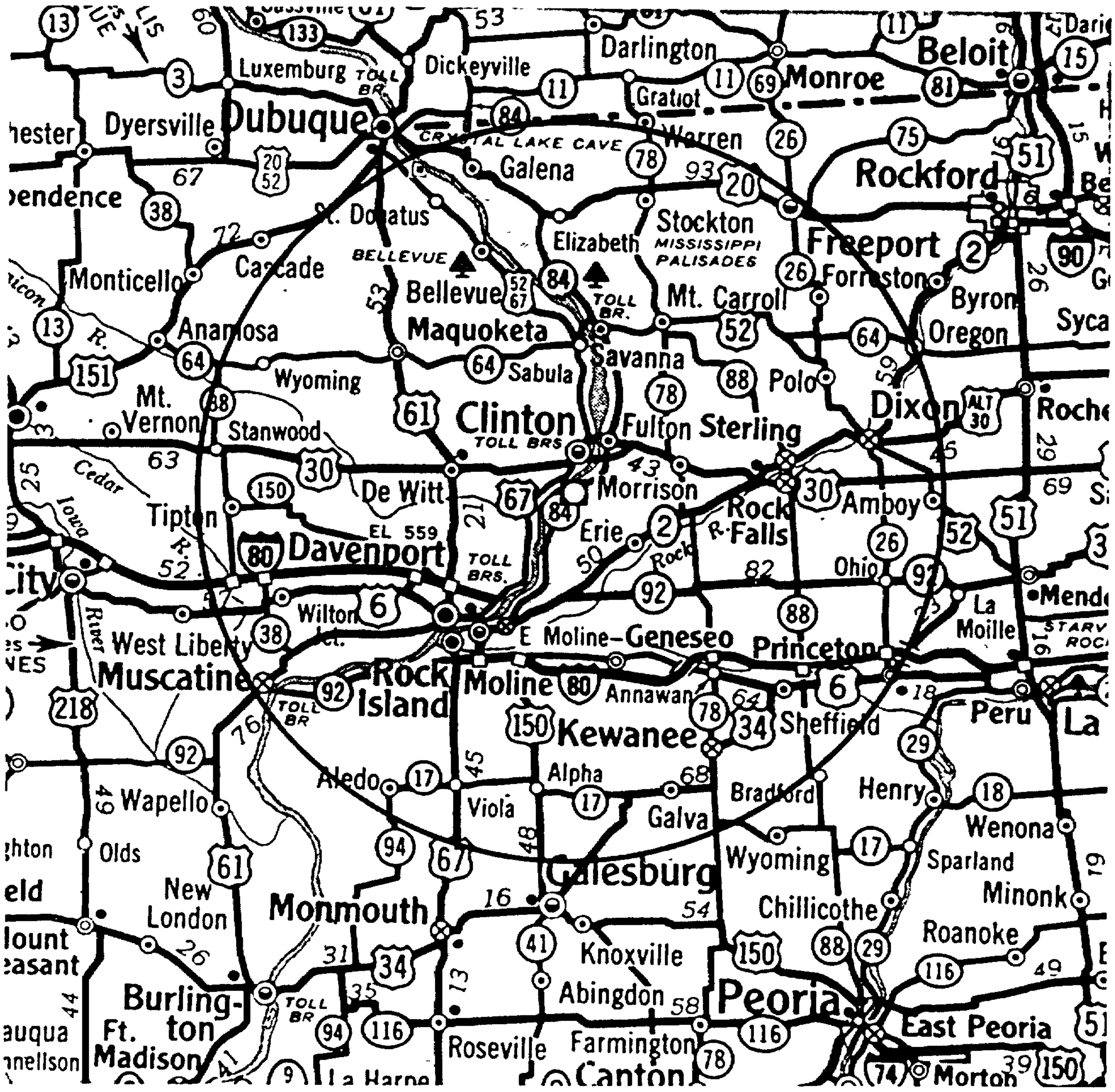


Fig. 3 Location of Quad-Cities Nuclear Stations
(Circle at 50 mile radius)

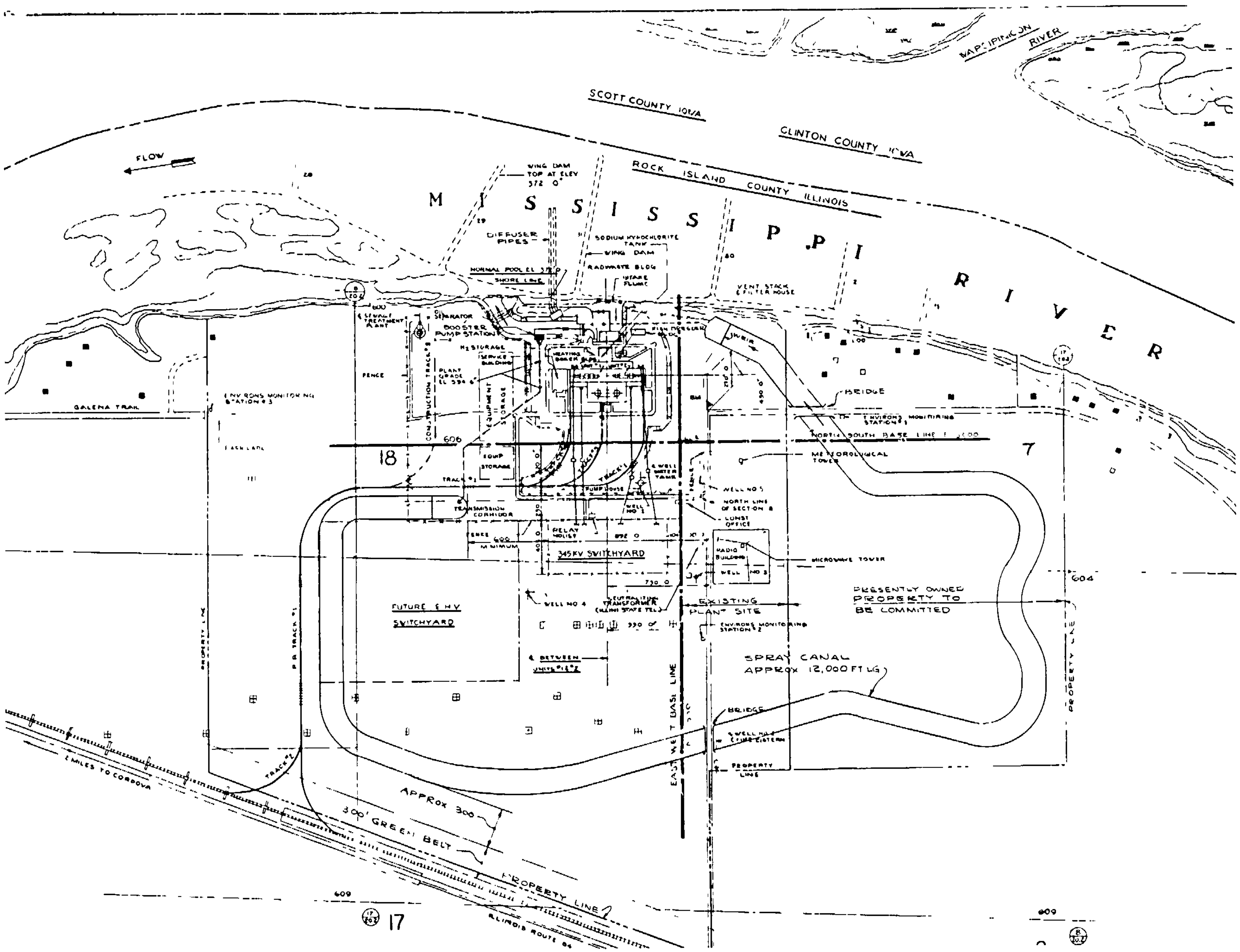


Figure 4a(18) Quad-Cities Nuclear Station Site Plan

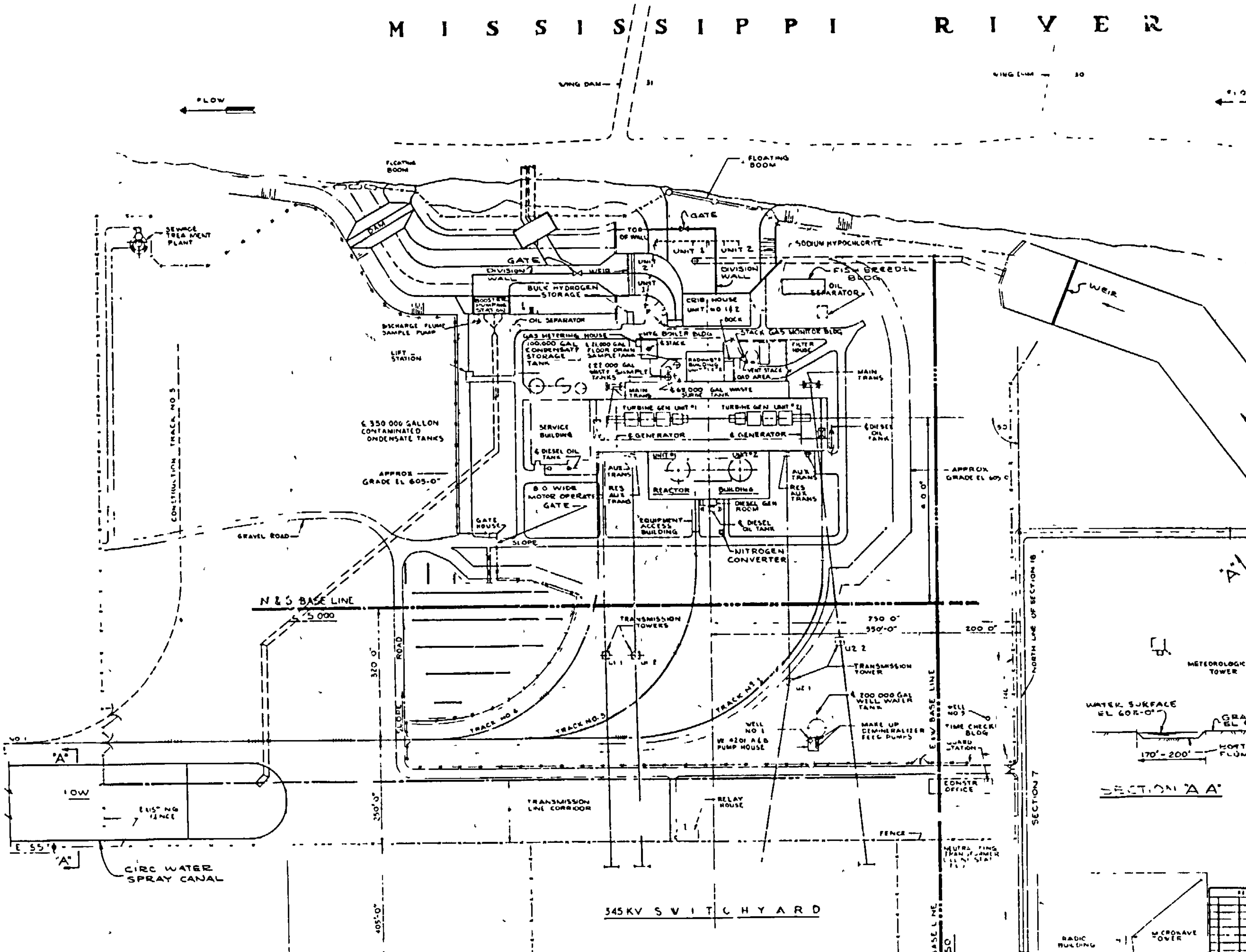


Figure 4b(18) Quad-Cities Nuclear Station Site Plan

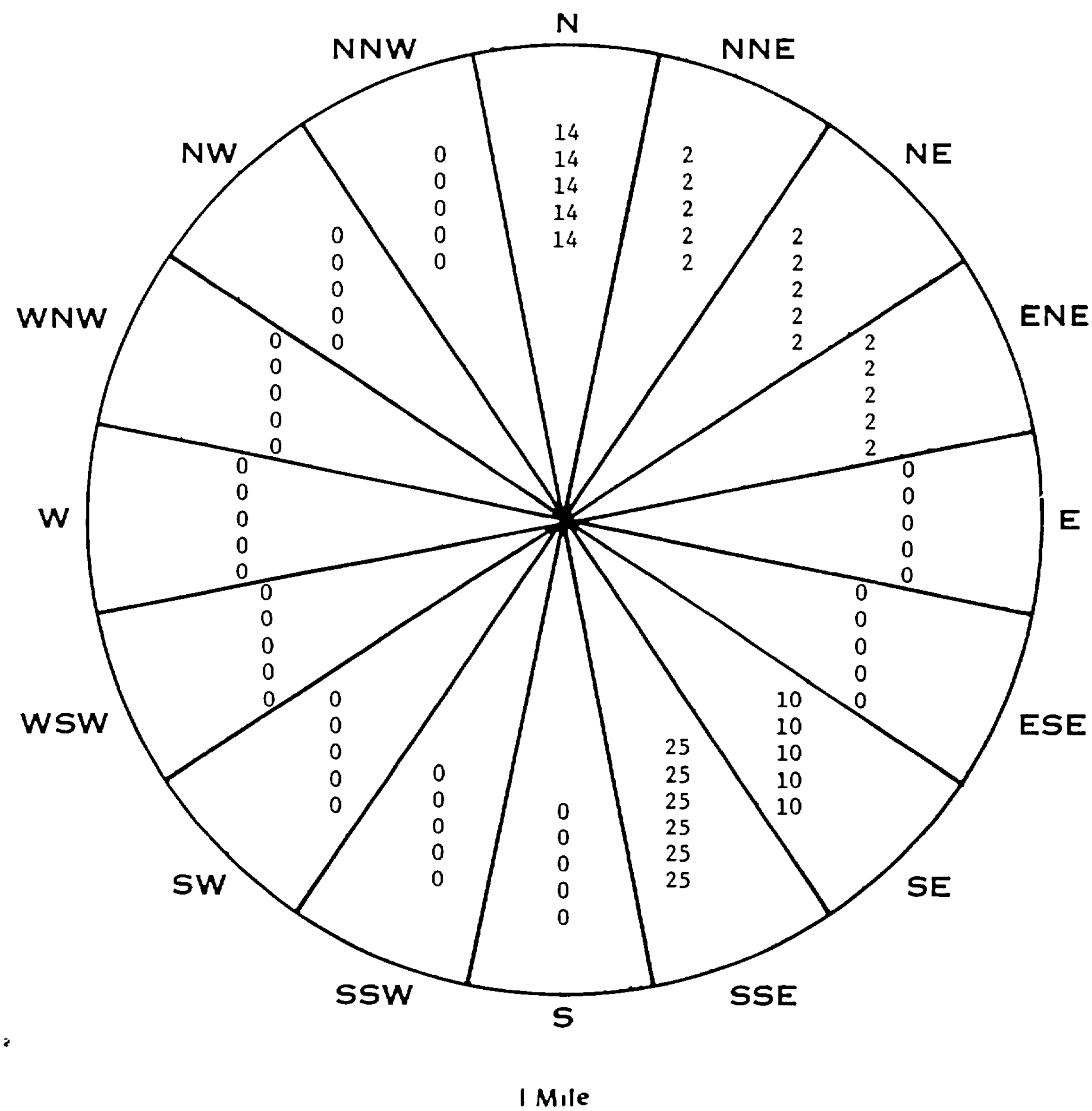


FIGURE 5a(23) PRESENT AND FUTURE POPULATION DISTRIBUTIONS (0-1 MILES)

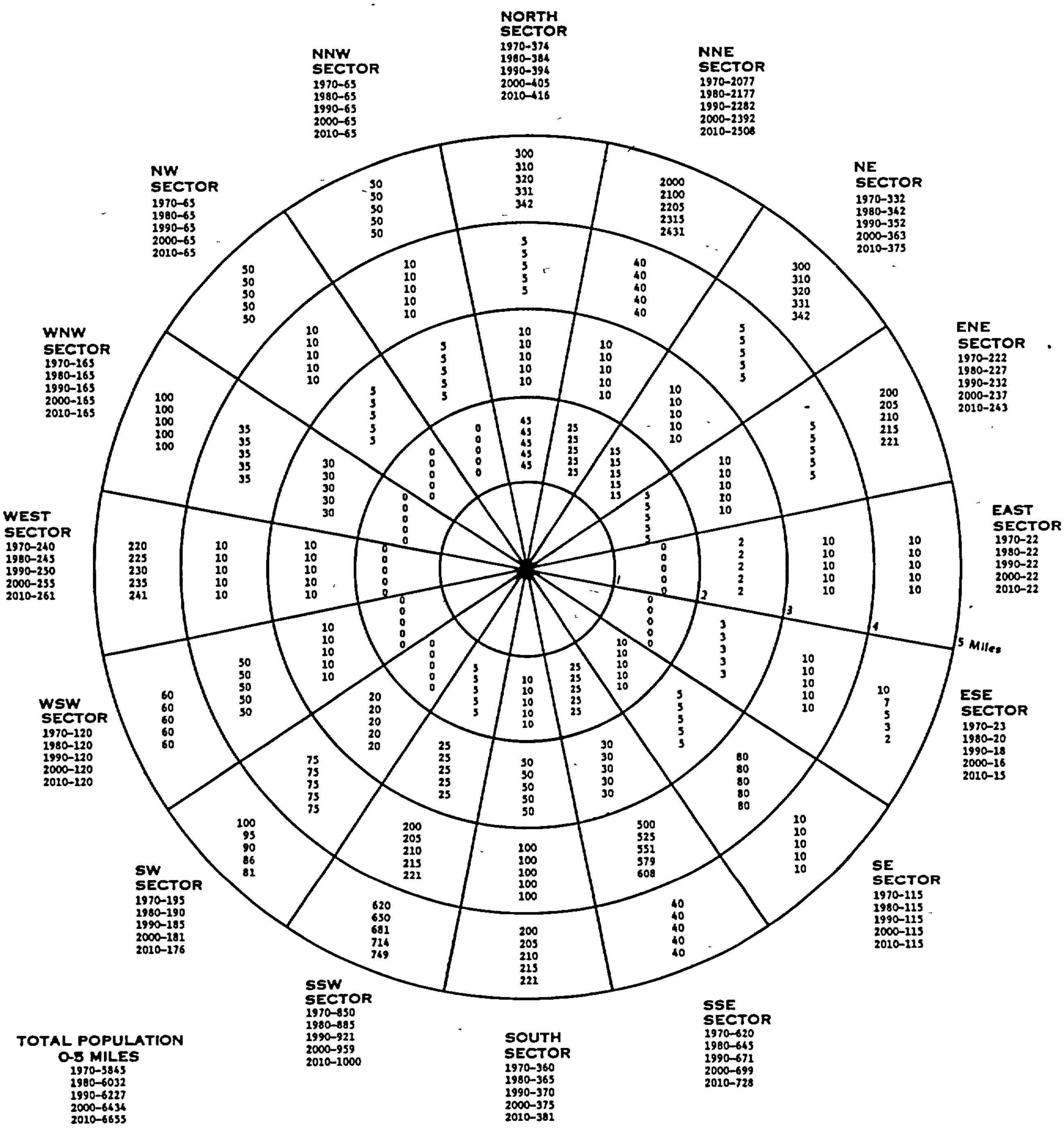


FIGURE 5b[23] PRESENT AND FUTURE POPULATION DISTRIBUTIONS (0-5 MILES)

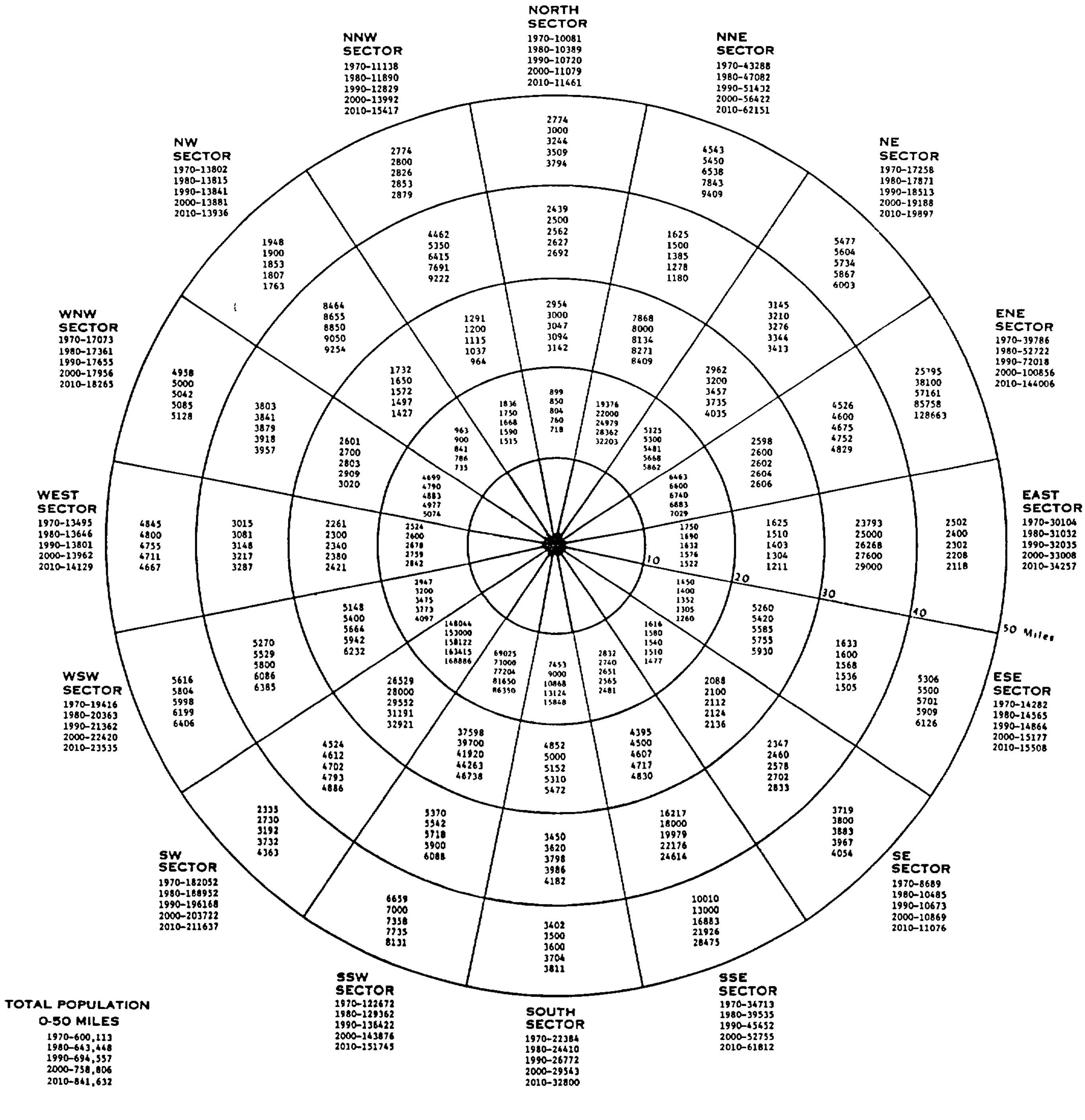


FIGURE 5c[23] PRESENT AND FUTURE POPULATION DISTRIBUTIONS (0-10 MILES)

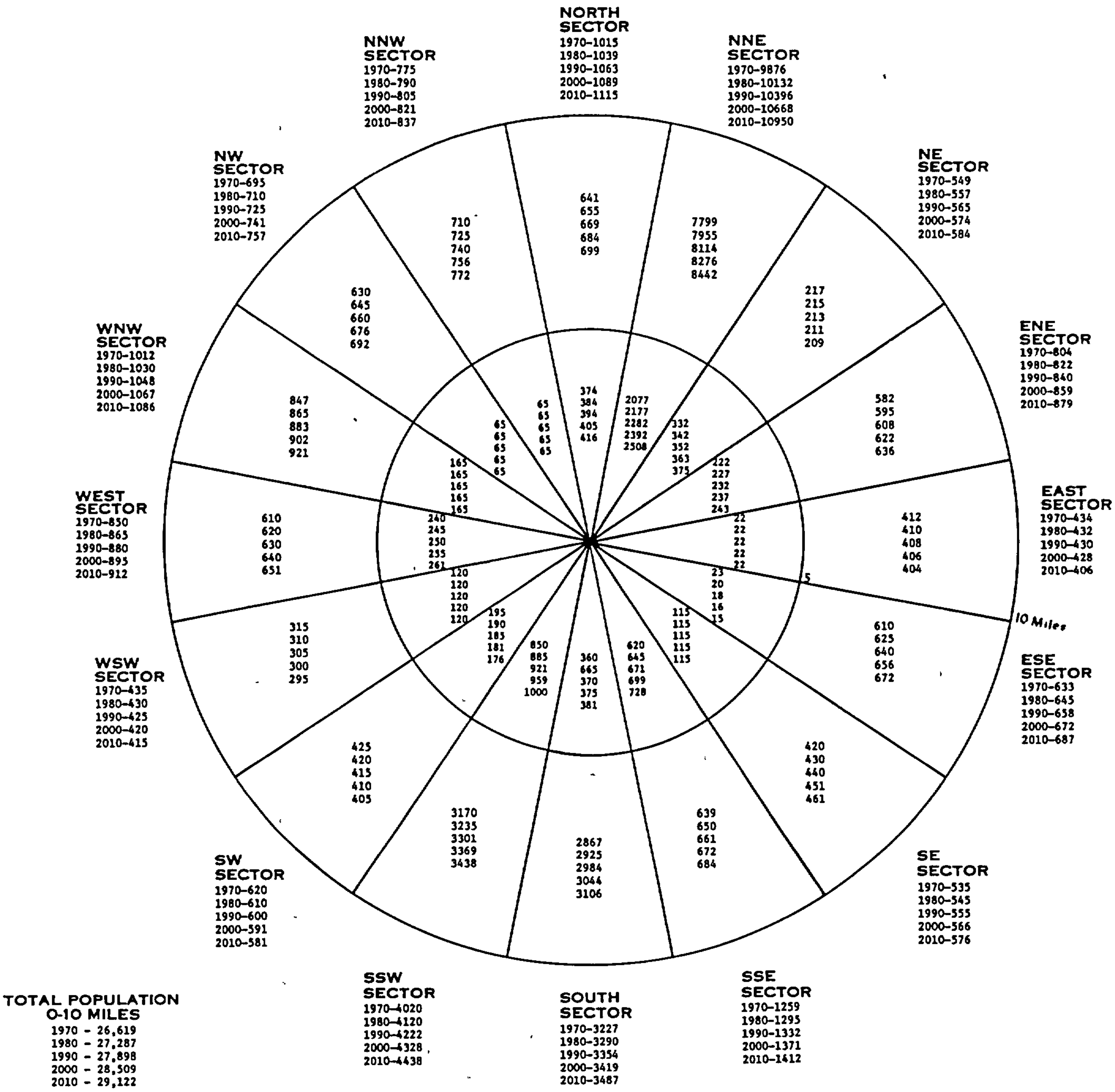


FIGURE 5d[23] PRESENT AND FUTURE POPULATION DISTRIBUTIONS (0-50 MILES)

An industrial park is located directly north of the station. Figure 6 shows the occupants of the park. The Nitrin plant has been closed down.

D. HISTORICAL SIGNIFICANCE

A review of the National Register of Historic Places indicated that there are no historical structures on the site. No known fossil deposits or archaeological materials are on the site or in the immediate vicinity. There is a historical site in Rock Island County - the Rock Island Arsenal located on Rock Island. Also, the birthplace of William Cody (Buffalo Bill) is near LeClaire, Iowa, about 8-1/2 miles southwest of the station. The operation of the station is not expected to affect these sites.

E. ENVIRONMENTAL FEATURES

The site elevation is 23 feet above the normal river level and 9 feet above the highest flood level recorded during the 92 years of record. Representative Mississippi River flows by month for Pool 14 are presented in Table 1. High flows result in the spring from melted snow and land runoff in the Upper Mississippi Basin. Maximum flows usually occur in April, the record being 307,000 cubic feet per second (cfs) on April 28, 1965. The lowest flows are observed in winter, usually in December or January. The record low was 6,500 cfs during December 25 to 27, 1933. However, this was prior to completion of the navigational dams in the upper Mississippi River. Since the completion of these dams in 1939, the minimum daily flow was 10,900 cfs.

Monthly maximum, average maximum and average water temperatures during the period 1962-70, measured at the Davenport, Iowa, water plant, are shown in Table 2. Similar temperature data for Pool 14 are not available. However, the temperatures in Pool 15 at Davenport, Iowa, 22 miles downstream from the station, are believed to be representative of those in Pool 14. Observations[24] in Pool 14 have shown that temperatures in sloughs can have about 12°F diurnal variation and, in one case, the slough temperature was about 18°F higher than in the main channel. It is reported[24] that the river temperature at Davenport has been measured at 85° or slightly higher about one tenth of one percent of the time.

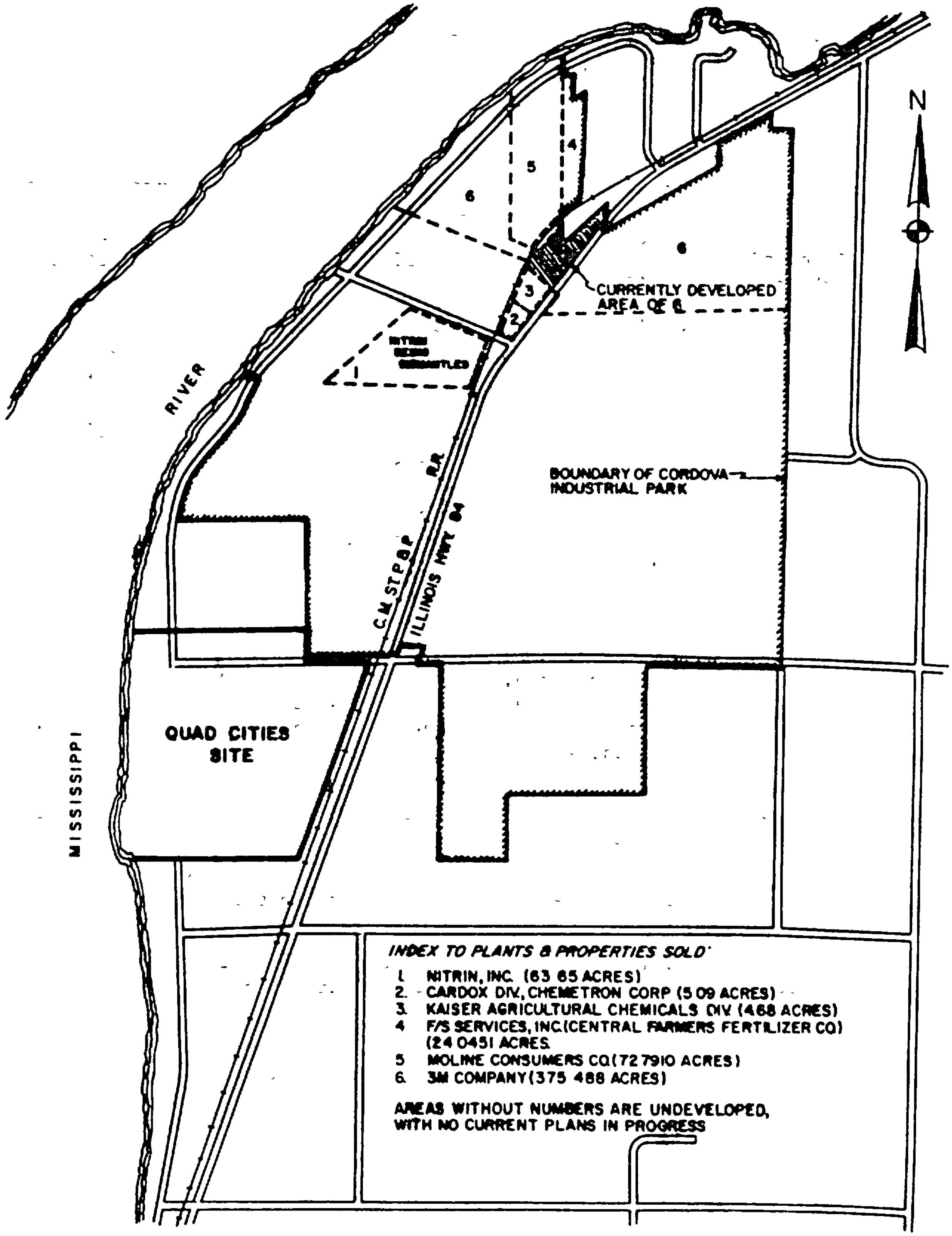


Figure 6. Cordova Industrial Park

TABLE 1

MONTHLY MISSISSIPPI RIVER FLOW[21]

Month	Mean[a,e] cfs	1-Day 90% Low Flow[b,c] cfs	7-day Low Flow[d] Once in 10 yrs. cfs
Jan.	25,800	17,000	15,900
Feb.	26,900	16,800	15,800
Mar.	49,000	24,800	20,500
Apr.	94,000	43,000	32,100
May	74,000	33,000	24,000
June	62,000	26,200	19,700
July	52,000	20,500	17,300
Aug.	35,000	17,800	15,700
Sept.	34,000	18,300	16,300
Oct.	34,300	18,000	15,400
Nov.	33,700	20,000	17,400
Dec.	27,000	17,500	16,100

[a] Only the record since 1938, for the present system of locks and dams, is considered here. These flows are measured at Clinton, Iowa. Actual flows at the plant are about 1 percent higher, due to confluence of the Wapsipinicon River.

[b] The one-day low flow which is exceeded 90 percent of the time for the period since 1938.

[c] The lowest daily flow since 1939 was approximately 11,000 cfs.

[d] The low flow for a period of 7 consecutive days, the lowest such value expected on a frequency of once in 10 years; statistic for the period since 1938.

[e] Average annual flow of record 46,800 cfs; average annual flow since 1938, 46,300 cfs.

TABLE 2

MONTHLY MAXIMUM, AVERAGE MAXIMUM AND AVERAGE WATER TEMPERATURE, 1962-70, AT DAVENPORT, IOWA WATER PLANT[22]

Month	Maximum (°F)	Average Maximum (°F)	Average (°F)
January	36	35	33
February	38	35	33
March	54	44	37
April	63	56	49
May	73	70	62
June	81	79	73
July	85	81	78
August	83	81	77
September	80	75	69
October	69	64	57
November	55	51	44
December	42	39	34

The land is rolling on both sides of the river with no topographical features which have any significant effect on local meteorology. The highest wind velocity officially recorded is 75 mph at Peoria (approximately 80 miles from the site). Eight tornadoes have been reported in Rock Island County in a 52-year period (1914-1965).

Water for industrial and home use in the region comes from both wells and the river. Ground-water sources in the area are from three aquifer systems:

1. Unconsolidated alluvial and outwash sand and gravel deposits,
2. Shallow Silurian dolomite formations, and
3. Artesian sandstone aquifers of Cambrian-Ordovician age.

Some wells within a few miles of the site pump at rates up to 700 gpm. These are in the upper aquifer at depths of 20 to 100 feet of the surface. The ground-water gradient typically causes it to flow toward the Mississippi River, except for periods of high river levels. Production from at least the high-yield wells can cause a ground-water gradient toward the well. The two known high yield wells (700 gpm capacity at 57 foot depths) are farm wells located 2 to 3 miles from the site boundary, which is far enough to be free of the influence of this gradient. The station has two deep wells which are used as a source of make-up water.[4]

F. ECOLOGY OF SITE AND ENVIRONS

1. Terrestrial

The applicants' supplemental environmental report[3] provides a review of the area terrestrial ecology. The area in which the site is located is in a sandy soil with little bushy or wooded area. The areas of major terrestrial interest are the river islands nearby and the area adjacent to the river in Scott and Clinton counties in Iowa. The islands are wooded and part of the wildlife area above the station has extensive sloughs and small lakes. Waterfowl use the Iowa area extensively and there is an abundance of mammals such as squirrel, rabbit, muskrat, beaver, raccoon, and mink.

The upper Mississippi River Wildlife and Fish Refuge, administered by the Bureau of Sport Fisheries and Wildlife, is located on the west bank of the river opposite the site. The Savannah-Clinton District of the refuge, which includes the northern half of Pool 14, reported peak populations of 60,500 ducks and 2,500 geese in 1965. These populations were present in this district of the refuge for a sufficient period of time to accumulate more than 2.5 million waterfowl-use days. A significant amount of food consumed by waterfowl using the refuge is produced in the marshes along the river.

The agricultural lands in the vicinity are used for grain crops and grass and forage crops for cattle.

2. Aquatic

Although municipal and industrial waste discharges from the Clinton, Iowa, area have occasionally resulted in excessive slime growths in the slough areas in the vicinity of the station, Pool 14 is a relatively unpolluted environment. Limited water quality analyses conducted by the applicants' consultant, Industrial Bio-Test Laboratories, Inc. (Bio-Test),[7,8] indicate evidence of nutrient enrichment primarily from agricultural runoff, but no large-scale pollution. Bio-Test studies during 1968-70 indicate that temperature, dissolved oxygen (DO), and ammonia nitrogen values in Pool 14 are less than the maximum limits established by the Illinois Sanitary Water Board.[20] Additional water quality data, including specific element analysis performed and evaluated by Bio-Test, suggest that sufficient baseline information is available to determine any future water quality degradation.

Pool 14 encompasses a variety of aquatic habitats and communities in the vicinity of the station. A recent report[19] covers the general history and provides a description of aquatic habitats from Hastings, Minnesota, to Alton, Illinois. Major Mississippi River habitats near the station according to Bio-Test[7,8] are the channel habitat, channel border habitat, side-channel habitat, river lake and pond habitat, slough habitat and island lake habitat. These habitats are chiefly defined by location, depth, bottom material, and vegetation.

The main channel in the vicinity of the station is characterized by a scoured sand bottom and the highest current velocity. Directly below the station along the Illinois shore are several small islands with adjacent, relatively quiet, shallow water areas (see Figure 7). Further downstream, across the main channel, are extensive areas of side channel and slough habitats. The 16 mile portion of the pool above the station has a large amount of side-channel and slough habitat, five or six times as much as that downstream from the station.

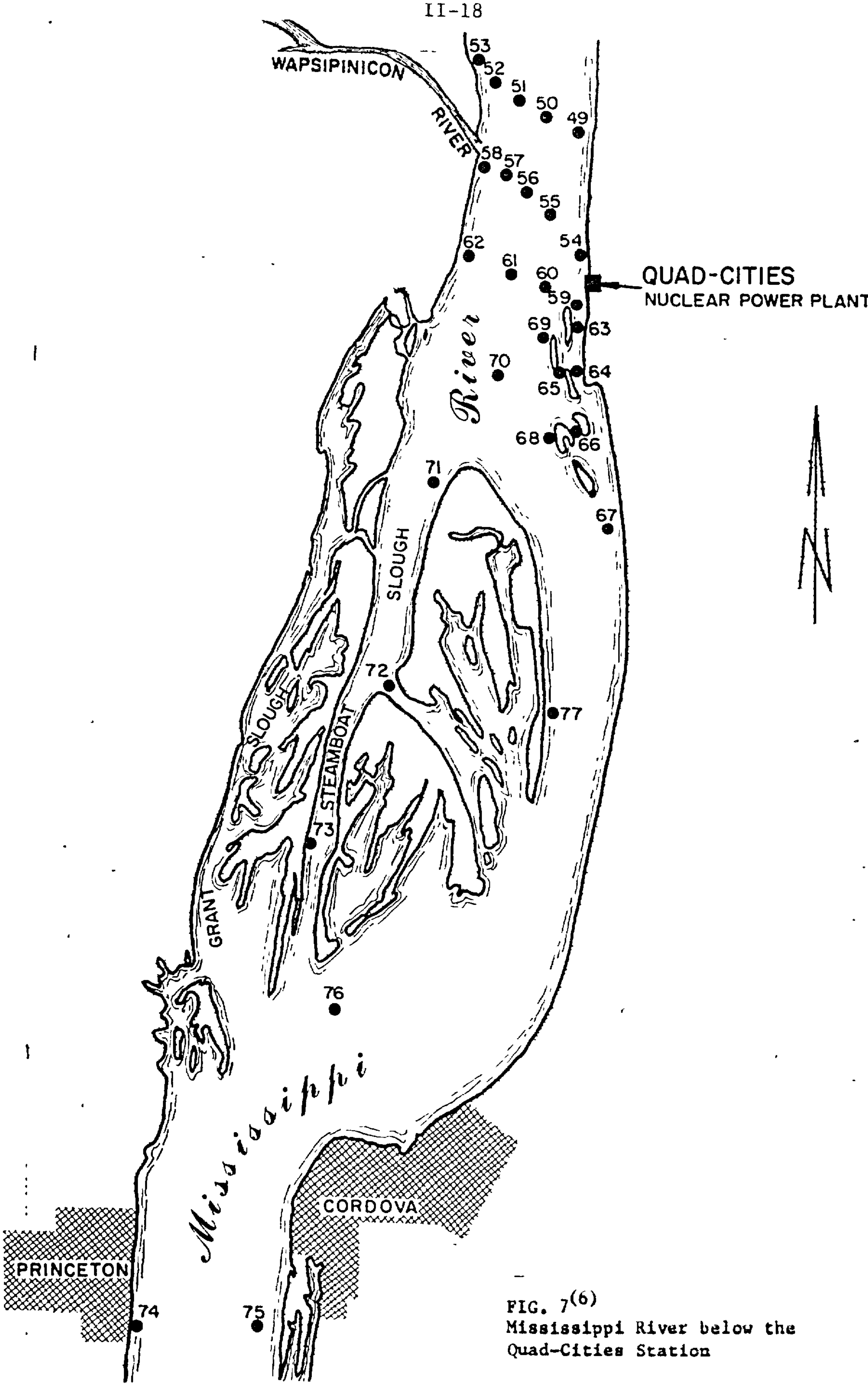


FIG. 7(6)
Mississippi River below the Quad-Cities Station

The applicants initiated preoperational environmental studies for the station in 1968. A preliminary study[6] has been followed by a continuing physical, chemical, and biological monitoring program conducted by Bio-Test.

Bio-Test's first report[7] was based on samples collected at 22 locations (the closest of these locations are indicated in Figure 7) in different habitats of Pool 14, from river mile 507.6 to river mile 501.3, during the months of August and November 1969, and April 1970. Measurements were made of coliform bacteria concentrations, phytoplankton, periphyton, and benthos populations, and various physical and chemical parameters. The results indicate that the benthos population density (animals per square meter) is relatively low in the main channel, whereas population density and species diversity is highest on rocky bottoms in areas of reduced current. The number of benthic animals in the vicinity of the station is dominated by insects, with fewer crustaceans, oligochaetes, and molluscs. The phytoplankton population (cells per liter) is dominated by diatoms. Blue-green algae never formed a major part of the phytoplankton.

Bio-Test's second report[8] is based on physical, chemical, and biological data collected at 35 stations in July and October 1970. The study covered an area in Pool 14 from 2 miles above the station to 13 miles downstream. This report is more comprehensive than the first in that additional water quality parameters were measured and the biological work included fish sampling and analysis of fish stomach contents as well as more intensive observations of phytoplankton, periphyton, and benthos populations. The report includes no zooplankton data but indicates that zooplankton and aquatic insects predominate in the stomachs of small fish. Diatoms comprised at least 80 percent of the total phytoplankton cell concentrations during both July and October 1970. No excessive growths of attached algae were reported. The benthos population generally consisted of organisms such as burrowing mayfly nymphs that are considered to be indicative of relatively unpolluted water, although at a few stations the pollution-tolerant tubificid worms appeared to be more numerous.

Other biological studies[10,15] have established the existence of relatively diverse and productive plankton, periphyton, and benthos communities supporting significant commercial and sport fisheries in Pool 14 and other pools in the Upper Mississippi River.

The locks and dams on the Mississippi River system effectively isolate adult fish populations except during periods of flood. Upstream migrations of species are hampered, whereas downstream drift occurs between pools. Serious ecological disturbances in one pool could possibly cause subsequent changes in the ecology of downstream pools, particularly since downstream drift is a major mechanism in energy transfer and dispersal of organisms. Although ecological changes resulting from locks and dams and industrialization have occurred, there remains a wide diversity of fish species in the river. In Pool 14 alone, 64 species have been identified. Recent surveys,[5] however, have collected fewer fish species, suggesting that the diversity may have decreased in recent years. Appendix C contains species lists of aquatic organisms identified in Pool 14 by Bio-Test Labs and the Illinois Department of Conservation.

A considerable amount of sport and commercial fishing occurs in Pool 14, about equal in size of catch by pounds per acre to that of adjacent pools. The combined value of this fishing was conservatively estimated[5] at about $150,000 for 1968, of which about one-third was commercial. It was estimated that 20,000 anglers spent 105,000 hours at Pool 14 in 1967 to catch 104,750 fish. The 16-year (1953-68) average annual commercial catch was 318,650 pounds.

Primary sport species in Pool 14 in approximate order of fisherman preference are bluegill and crappie, catfish, and sauger and walleye (Table 3). Certain sport species, such as the northern pike, yellow perch, walleye and sauger occur in limited numbers; however, they are more numerous further upstream (e.g., Pool 4). Although these species do appear in pools as far downstream as Pool 18, they are apparently not well adapted to conditions in Pool 14 and pools further southward. Thus, there appears to be a succession of species composition occurring in a downstream direction as a result of changing environmental conditions.

Commerical catches (Table 4) are primarily composed of carp, buffalo, catfish, and drum, with catfish being the preferred species (highest market price). On the basis of the Bio-Test studies,[7,8] it appears that the channel habitat in Pool 14 is the least productive in numbers of organisms and does not serve as a major feeding or spawning area. The side-channel and slack water habitats show greater productivity and probably provide a more favorable environment for reproduction and feeding. These habitats would be especially favorable to fish because of the abundance of prey organisms, relatively weak river currents, variable water depth and sufficient cover for protection against predation. For the majority of fish species occurring in Pool 14,

TABLE 3

SPORT CATCH STATISTICS - POOLS 4, 13, 14, 18[5,14]
% TOTAL CATCH. ( ) INDICATES FISHERMAN PREFERENCE RANK

Species	Pool 4 (1967)	Pool 13 (1967)	Pool 14 (1956-58)	Pool 18 (1967)
Walleye and Sauger	33.3(1)	1.9(3)	8.7(3)	6.3(3)
Carp	0.2	2.3	2.2	3.0
Catfish	6.4	4.9(2)	6.8(2)	40.5(1)
Whitebass	7.0	9.8	9.4	8.9
Drum	2.8	12.4	9.9	12.3
Largemouth bass	1.1	1.9	1.6	1.5
Bluegill-crappie	44.3(2)	57.4(1)	48.5(1)	24.1(2)
Yellow perch	1.4	0.8	0	0
Bullhead	0.2	8.3	7.8	3.2
Northern Pike	2.1(3)	0.1	0	0
Other	1.2	0.2	5.1	0.2
	100.0	100.0	100.0	100.0

TABLE 4

COMMERCIAL FISHERY STATISTICS - POOLS 14, 15, 19[5]
TOTAL CATCH (lbs) IN 1968

Species	Pool 14	Pool 15	Pool 19
Carp	80,000	17,000	382,000
Buffalo	129,000	19,000	197,000
Catfish	78,000	11,000	149,000
Drum	34,000	9,000	120,000

spawning begins in early spring and extends into summer and probably occurs to the greatest extent in the slack water areas. Specific spawning times and locations (e.g., the exact month and slack water site) for the fish species in this pool are not well known.

The present situation is that, in spite of the above data, the biology of Pool 14 is not adequately characterized to make a complete analysis of the impact of station operation. Since few data are available on reproductive behavior, feeding habits and growth characteristics of fish species in any of the pools, and preoperational reports by Bio-Test[7,8] are lacking in the specific information and interpretation necessary, it is not possible at this time to determine with sufficient accuracy which species may be stressed or even afforded competitive advantage as a result of station operation.

III. THE PLANT

A. EXTERNAL APPEARANCE

The major buildings are metal sheathed structures with the metal panels colored in subdued tones. Figures 8 and 9 are photographs which show the type of construction at the station along with the locations of the water intake slightly to the right of center foreground in Figure 8 and the discharge canal directly to the right of the intake. The discharge canal (now referred to as the discharge bay) has been blocked off at the point where the condenser cooling water entered the river. The condenser cooling water now passes from the discharge bay to the river via a diffuser-pipe located approximately midway in the bay. The large building houses both turbine generators with the high-day portion toward the background having the reactor units.

Figure 9 shows the site location in relation to Illinois Route 84 which is the road running left to right in the background. The highest portion of the major building, the stack, and the transmission lines are clearly visible from Route 84. Much of the view of the station is obstructed by the evergreen trees along the highway. The spray-canal will be located in the open space between the station and Route 84 as indicated in Figure 4.

The transmission line towers used on the site are the four-legged open steel structures customarily used by utilities. The towers across the river are quite tall because of the long span between them. The river crossing towers are painted red and white to increase their visibility.

B. TRANSMISSION LINES

Four 345 kV transmission lines originate at the station. Two lines are owned by the Commonwealth Edison Company, and both terminate at the existing Nelson Transmission substation about 40 miles due east of the station. The use of two lines over slightly different routes (the north line is 39.7 miles in length, the south line 41.9 miles) provides a more reliable 345 kV system between the station and the Nelson Substation which in turn feeds into the Chicago area. The other two lines are owned by the Iowa-Illinois Gas and Electric Company and both terminate at existing substations; one travels

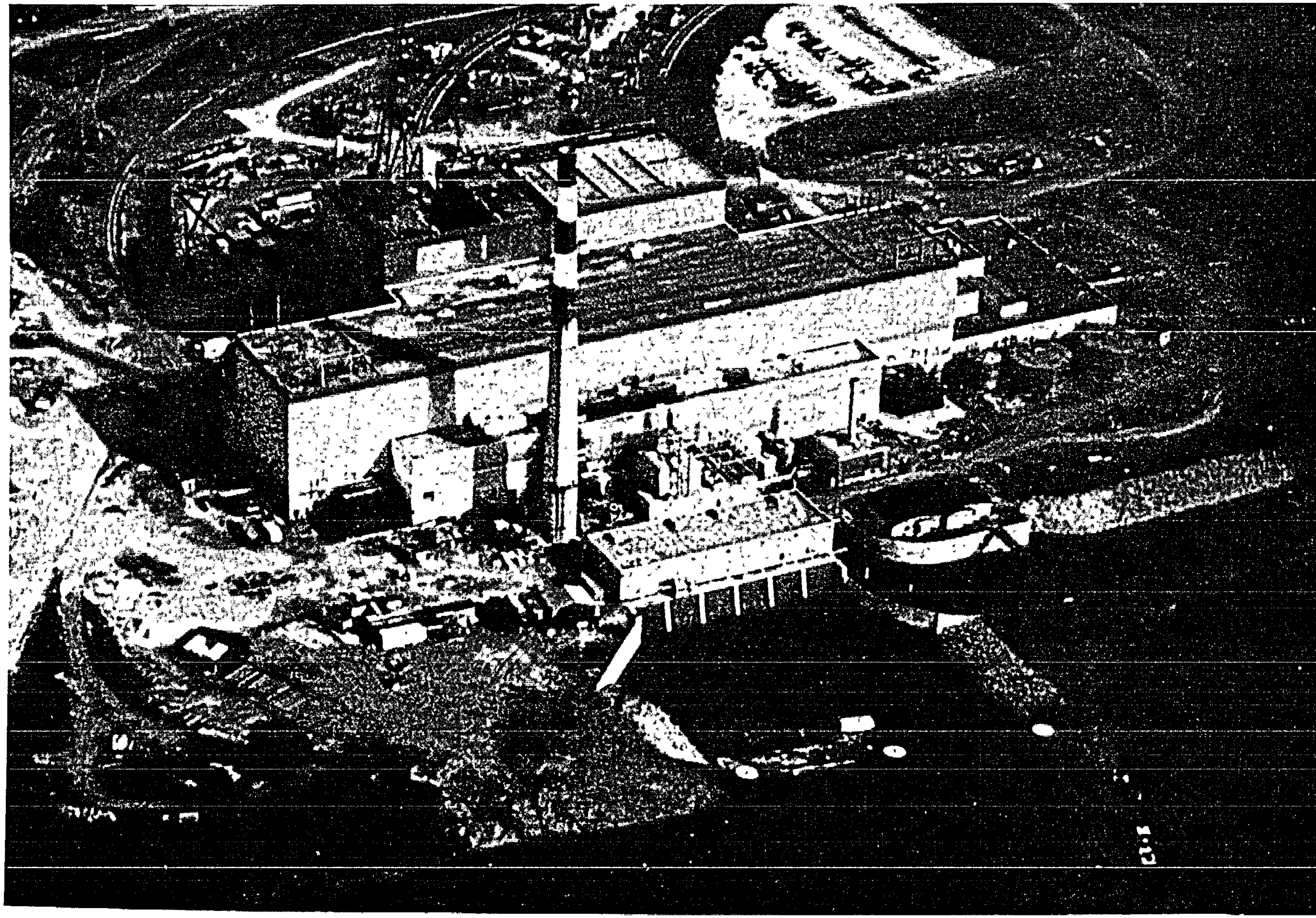


Figure 8. Aerial view of the Station

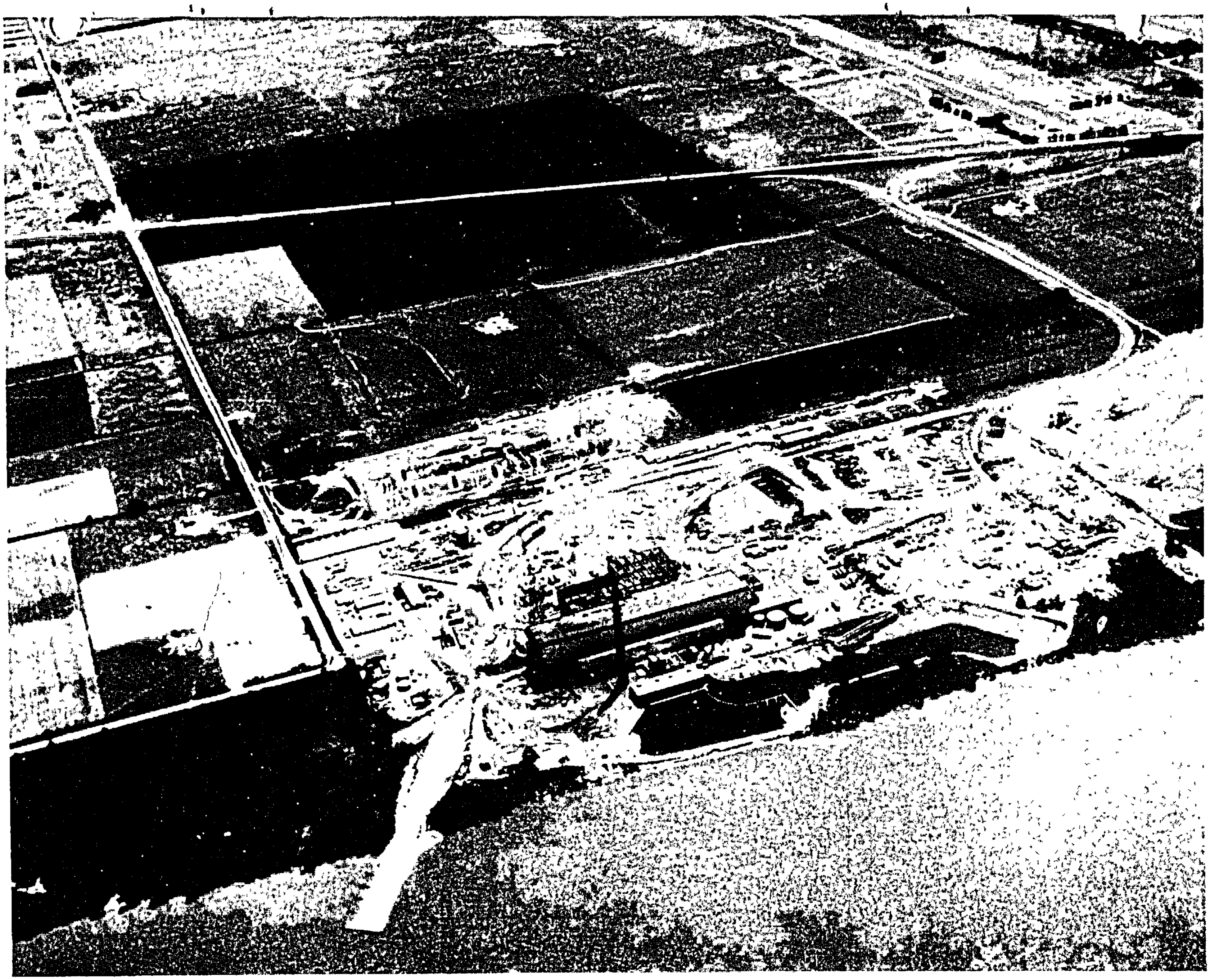


Figure 9. Aerial view of the Station and the Site

17.5 miles to the Iowa-Illinois Gas and Electric Company's Substation 39 in Rock Island County, Illinois, the other 27 miles to Substation 56 near Davenport, Iowa. These lines were planned and would have been built to an alternate source of power in the area had the station not been built.

The two Commonwealth Edison Company transmission lines are generally of single circuit steel tower construction (Figure 14, See Section V A 3) designed to exceed the minimum strength requirements of the latest revision of the Illinois Commerce Commission General Order 160, which is identical to the National Electrical Safety Code requirements for construction of transmission lines. The Iowa-Illinois Gas and Electric Company's transmission line to Substation 39 generally utilizes two-pole wood H-frame construction, designed to meet requirements of the Illinois Commerce Commission General Order 160 and the National Electrical Safety Code requirements for the construction of transmission lines. The other Iowa-Illinois Gas and Electric Company's line which terminates at Substation 56 near Davenport, Iowa, is installed on single circuit steel towers, and is designed to meet the requirements of the National Electrical Safety Code.

In Illinois the transmission lines parallel existing public roads for limited distances, and are well set back so that prolonged views from the roads are avoided. Although the lines cross public roads at times, no crossings coincide with intersections. The terrain through which the lines run is predominantly farmland with few wooded areas, and no parks or scenic areas are near the lines.

In Iowa, farmland is the predominant land of passage, with a 0.4 mile region of dense timber and a lesser distance of sparse timber traversed. The overall effect on the natural environment is minimal. Because of topography and land use, maintenance of the transmission lines should present no adverse environmental effects.

C. REACTOR AND STEAM-ELECTRIC SYSTEM

The station has two forced-circulation boiling-water reactors and turbine generators supplied by the General Electric Company. The Sargent and Lundy Company is the architect-engineer. Each reactor has a thermal output of 2,511 megawatts thermal (MWt) with a net electric output of 809 megawatts net electrical (MWe).

The reactor fuel is slightly enriched (2 to 3 percent by weight) uranium oxide pellets sealed in Zircalloy-2 tubes. Water is both the moderator and coolant. Two recirculation loops force reactor water through jet pumps and then up through the reactor core, where steam is generated under a pressure of about 1,000 pounds per square inch (psi). The saturated steam passes to the turbine, where some of the thermal energy is converted to mechanical energy and, in turn, by means of the generator to electrical energy. The exhaust steam is condensed and then pumped through demineralizers back to the reactor vessel. The water used to condense the steam is a separate system which does not come in contact with the reactor water steam. The negative pressure under which the steam side of the condenser operates assures that any leaks would go from condenser cooling water to reactor water and will not permit radioactivity to escape into the condenser cooling water. The power of the reactor is controlled by movement of control rods and by the rate of forced circulation of the water in the reactor vessel.

Nuclear power plants operate on the same thermodynamic principle as fossil-fueled power plants in which thermal energy is converted to electrical energy. Approximately two-thirds of the heat produced in the water reactors must be rejected to the environment, one-third is recovered as electrical energy.

Fission products formed in the fuel elements normally will be contained within the sealed Zircalloy-2 tubes. A second barrier to the release of fission products from the reactor system is provided by the primary coolant system for the reactor. The coolant system, in turn, is housed within primary containments for each unit, consisting of two interconnected, leak-tight, steel pressure vessels. In the event of a loss-of-coolant accident, the primary containment serves as a third barrier to the release of fission products. An additional level of control is provided by the common reactor building, which includes the primary containment for each unit, storage pools for spent fuel, and components of the plant-engineered safety features. Emergency core-cooling systems are provided to protect the reactor if a leak occurs in the primary coolant systems.

D. EFFLUENT SYSTEMS

1. Heat Removal

As previously described, two-thirds of the heat generated by the station is released to the environment. The original plan of operation was to release this heat to the Mississippi River water by a once-through cooling system. Under this system, full power operation of both generating units at a total of 5022 MWt will cause a 23°F temperature rise in 2270* cubic feet per second (cfs) of Mississippi River water, the maximum flow through the station (the average river flow is 46,800 cfs, see Table 1). At a lower station power level, the temperature rise is proportionately lower as long as the station cooling water flow stays at 2270 cfs (e.g., at 50 percent of full power, about 11.5°F temperature rise; at 20 percent of full power, about 4.6°F temperature rise). While the original design of the reactor and steam-electric plant (including the condenser and its cooling-water system) has been retained, the means by which the heat is dissipated to the environment has undergone several changes. These have come about out of further considerations of environmental impact. The outcome of these changes is that the station (both units) is to operate most of its life with a closed-cycle (evaporative) cooling system, with an open-cycle (once-through) system as back-up. For the closed-cycle system, only a small fraction of the above coolant flow is required as river intake (about 120 cfs) and only a small fraction of the station heat release (about 5 percent) reaches the river. The major heat release to the environment is by evaporation of river water into the air, where the water vapor is carried away by natural air movements. Because initial operations (first 3 years) will employ other means of heat dissipation, the description of the heat removal systems will here follow the chronological order of their consideration. After a brief historical outline, the function of each system will be discussed in turn.

The original system was a once-through cooling system with a low-velocity open canal. With this system, condenser-cooling water would go to the cooling water discharge canal, fall over a 3-foot weir, and pass to the river. The discharge canal is 600 feet long and about 150 feet wide. An associated adjustment of the wing dam (#29 in Figure 4a) was designed to direct the flow into the river at about 45° to the downward river flow. Early model studies demonstrated that the floating plume would frequently carry to the Iowa shore and into the slough area on that side and, further, would not meet the Illinois standard of no more than a 5°F rise in river water beyond a mixing zone of 600 feet. In order to meet this standard, adoption was made of an alternate proposal for the once-through cooling, the diffuser-pipe discharge system.[2] The diffuser-pipe system (sometimes referred to as jet-diffuser) will induce mixing of the warm water with the river flow. The diffuser-pipe consists of two multiport discharge pipes buried in the bottom of the river with all discharge ports located in the main (i.e., deep) channel. The reference design of the diffuser-pipe system is illustrated in Figure 10.

*The full station river water flow is 2270 cfs. Of this 2100 cfs is through the condensers and 170 cfs in service water.

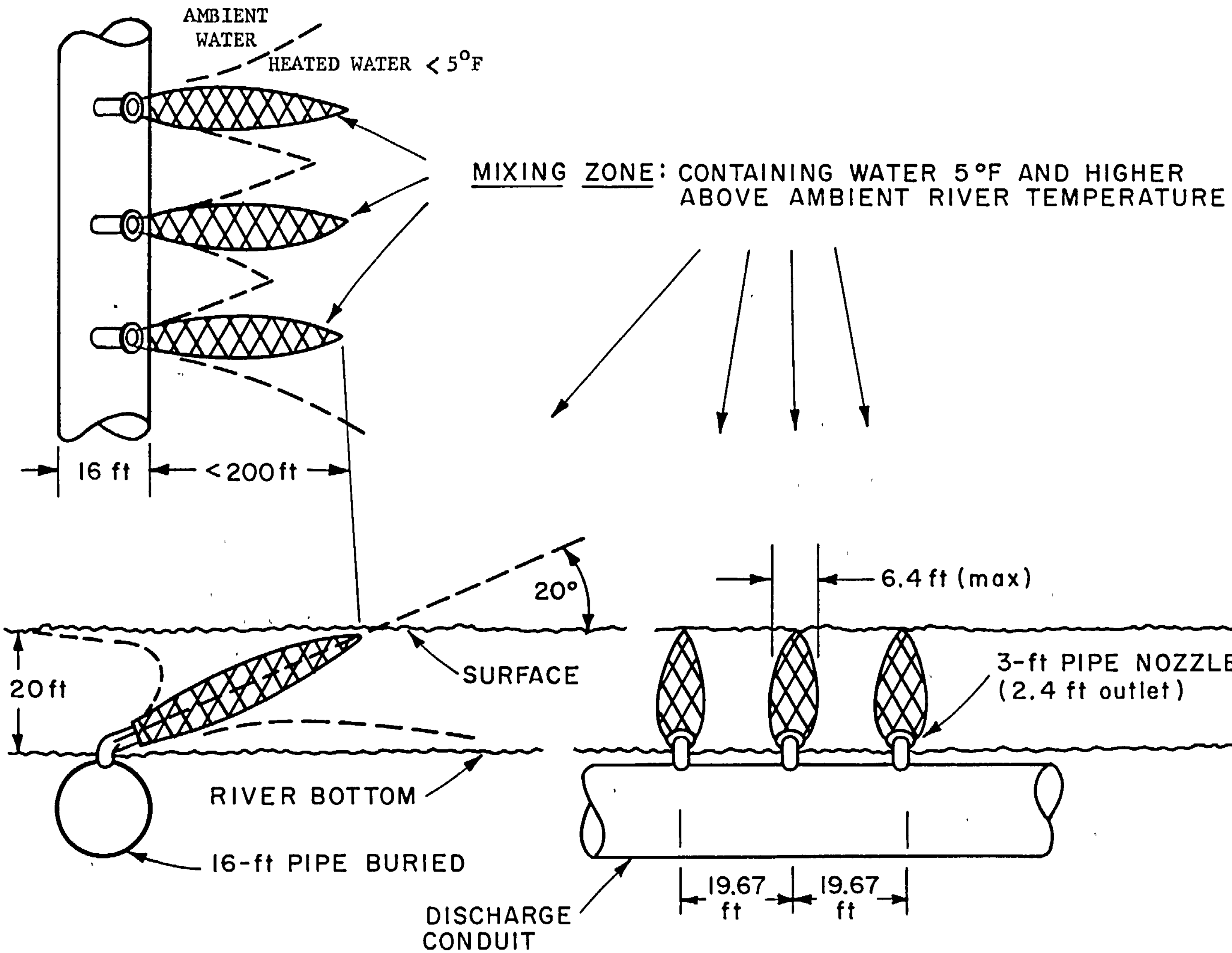


Figure 10. Diffuser Pipe System and Thermal Plumes (not to scale)

At the time the applicants applied for an interim license[12] for operation up to 50 percent of full power, the discharge canal had been constructed and the diffuser-pipe system was to become operational in the future. Pending construction of the diffuser, the applicants stated that the best immediate alternate was to close off most of the open end of the discharge canal to create a relatively narrow opening. This is referred to as the "necked down, side jet" discharge system[12] or the "side jet" discharge system.

The Illinois Pollution Control Board[7] granted the applicants a permit to operate the station using the side-jet discharge, at 50 percent of full power. The permit extended for two years from November 15, 1971 and granted a temperature variance from the state standards[9] only until April 1, 1972. This would have permited operation of the station, assuming all other regulatory requirements are met, at 50 percent of full power until April 1, 1972. (After this date, supplemental cooling would have been required, unless the power level were lowered appropriately, since the state temperature standards permit no more than a 5°F temperature rise above ambient outside a 600 foot mixing zone.) The applicants' supplemental environmental report[4] provides modeling data which indicate that operation at 50 percent of full station power would violate the state temperature standard if the side-jet discharge system was the only cooling system used.

After several hearings, the Iowa Water Pollution Control Commission, on December 29, 1971,[8] granted a permit to operate the station at full power with the diffuser-pipe system but conditioned operation in accordance with a set of guidelines. They were: (a) construction of a spray canal system for a closed cycle cooling system for one unit within 28 months; (b) establishment at a hearing, to be held within 36 months, that operation to date has not caused any damage to the environment and that it is not expected to cause such damage; and (c) if evidence of damage exists at this time, the entire plant would be required to have closed-cycle cooling.

On March 27, 1972, a settlement was reached[24] between the applicants and the parties to the Quad-Cities suit whereby the applicants agreed to provide closed cycle cooling for one unit by May 1974 (a provision similar to that above for Iowa) and to provide closed cycle cooling for the second unit by May 1975.[25] This agreement keeps the diffuser pipe system operable after May 1975 and allows its operation when "in the judgment of the utilities, closed cycle operation will result in a threat to public health and safety," and "whenever (i) a malfunction or other physical impairment, such as freezing, of the closed-cycle cooling system occurs which prevents operation of the Quad-Cities Station at its operating capacity as scheduled from time to time, and (ii) if the utilities cannot reasonably supply their customers' energy needs by using other sources of energy within their generating system." The States of Illinois and Iowa have agreed to these operating conditions. Operation of the diffuser-pipe after the completion of the spray-canal shall be controlled by the Technical Specifications which will be a part of any license issued.

On April 25, 1972, the Illinois Pollution Control Board granted[26] a temperature variance from the state standard (SWB-12 as amended by #70-16). This variance extended to August 15, 1972, and covered both the initial full power testing of each unit separately and up to full power operation of both units, but effluent temperatures were not to exceed ambient river temperatures by more than 12°F, as a last resort to meet demand in the period to August 15. The August 15 date was selected as a reasonable date at which the diffuser-pipe system would be operable. Our evaluation[35] of the situation indicated that for the expected summer peak power demands, limited operation of each unit up to a maximum of 90 percent of rated power was necessary to avoid an adverse effect on the public interest. Although such operations would likely cause an adverse impact on the quality of the environment, these impacts are such that full redress is expected.

a. Condenser Cooling Water Intake

Cooling-water intake for the condensers of both units is provided by an intake canal extending into the river. The dimensions of the canal are approximately 235 ft long, 180 ft wide, and 12 ft deep at the point of juncture with the river (see Figure 8). For once-through operation with either the side-jet or the diffuser, the full flow requirements of the condensers are obtained directly from the river via this intake canal. For closed-cycle operation of one or both units, the intake canal is partially closed off from the river by control gates and recycle water from the exit of the spray canal is conducted into the inlet canal near where it connects with the forebay of the screenhouse, where screens and pumps are located as part of the water intake system for the condensers. Each unit can be operated on open or closed cycle.

At the maximum station cooling water flow rate of 2,270 cfs, the entrance velocity to the intake canal is calculated by the staff to be about 1 foot per second. This velocity will be nearly the same with the spray-canal in operation. A floating boom which extends 33 inches beneath the surface is provided at the mouth of the canal to deflect floating material. It may also help to reduce the entrainment of floating fish eggs, larvae and fry. A view of the intake canal is given in Figure 8 (the gate has not yet been installed). A site plan that shows the changes required to permit the operation of the spray-canal is given in Figure 4a.

Between the floating boom and the condensers there is a row of vertical metal bars, commonly referred to as a trash rack. The bars are spaced 2-1/2 inches apart and extend from about 20 feet above the waterline to the bottom of the intake canal. The purpose of the trash rack is to collect and remove large pieces of debris that get past the floating boom.

Each condenser pump is further protected by a set of traveling screens with a 3/8-inch mesh. These screens change positions at preset time intervals or when activated by a buildup of pressure due to the collection of debris. The screens collect the smaller bits of debris that get through the trash racks. They also prevent organisms larger than the mesh from passing through the pumps and condensers.

b. Condenser Passage

Six pumps take water from the intake canal and force it through the secondary side of the condensers at 2,100 cfs. The exhaust steam from the turbines flows through the primary side of the condenser where it is condensed. This water is returned to the reactor to be reheated. The heat released by the condensed steam heats the cooling water and the service water to a maximum of 23°F above the incoming temperature. As previously stated, the negative pressure in the turbine exhaust and in the primary side of the condenser assures that leakage in the condenser will not release radioactivity from the turbine to the river.

The condenser tubes are cleaned by periodically injecting sodium hypochlorite solution into the water as it enters the condenser. Details of the sodium hypochlorite injection are given in Section III.D.3.

c. Condenser Cooling Water Discharge

(1) Side-Jet*

The side-jet is illustrated and discussed in the applicants' Supplemental Report.[4] Operation of the station at 20 percent of full power utilizing the side-jet discharge has been evaluated.[11] The side-jet is formed by driving sheet metal piling to block the open end of the discharge canal except for a 35 foot wide opening in the center of the canal. The water velocity through the opening at 2,270 cfs is about 4.4 feet per second and this relatively high velocity will aid in mixing the discharged condenser cooling water with the river water.

The model studies, performed at the University of Iowa[3,4,19] for the applicants, show that with the station at 50 percent power (and 2,270 cfs station cooling water flow) the thermal plume will extend to the opposite shore with a surface temperature about 3.5°F above ambient. The canal discharge temperature under this condition of 50 percent of power is 11.5°F above ambient. The river flow which allows the plume to extend across the river is the lowest on record since 1939 (11,000 cfs). At this low river flow, water 2 to 3°F above ambient may enter the Iowa slough area (see Figure 7) between the station and Princeton, Iowa. As river flow increases to a level which is exceeded 60 percent of the time (30,000 cfs, see Figure 12), the increased main channel velocity keeps the plume out of the Iowa sloughs. As river flow increases from 13,500 and 30,000 cfs the plume shifts toward the Illinois shore and a group of small islands located in a zone 700-4000 feet downstream are surrounded by surface waters in the temperature range of 5 to 8°F above ambient. At a depth of six feet this water ranges from about 2 to 6°F above ambient. Figures 11a through 11d illustrate the results of the model studies.

Below these small islands the main river channel has turned from the Iowa to the Illinois side of the river and the plume from around the islands enters the main river channel. The University of Iowa model did not extend below the islands so that only estimates can be made of the temperatures below that region. A staff estimate of the river temperature increase downstream from the small island zone at 50 percent station power is 5°F maximum for a surface layer that might persist for as long as a mile beyond the islands. The overall temperature effect after mixing on Pool 14 at 50 percent station

* The side-jet is no longer used. It has been inoperable since August 2, 1972.

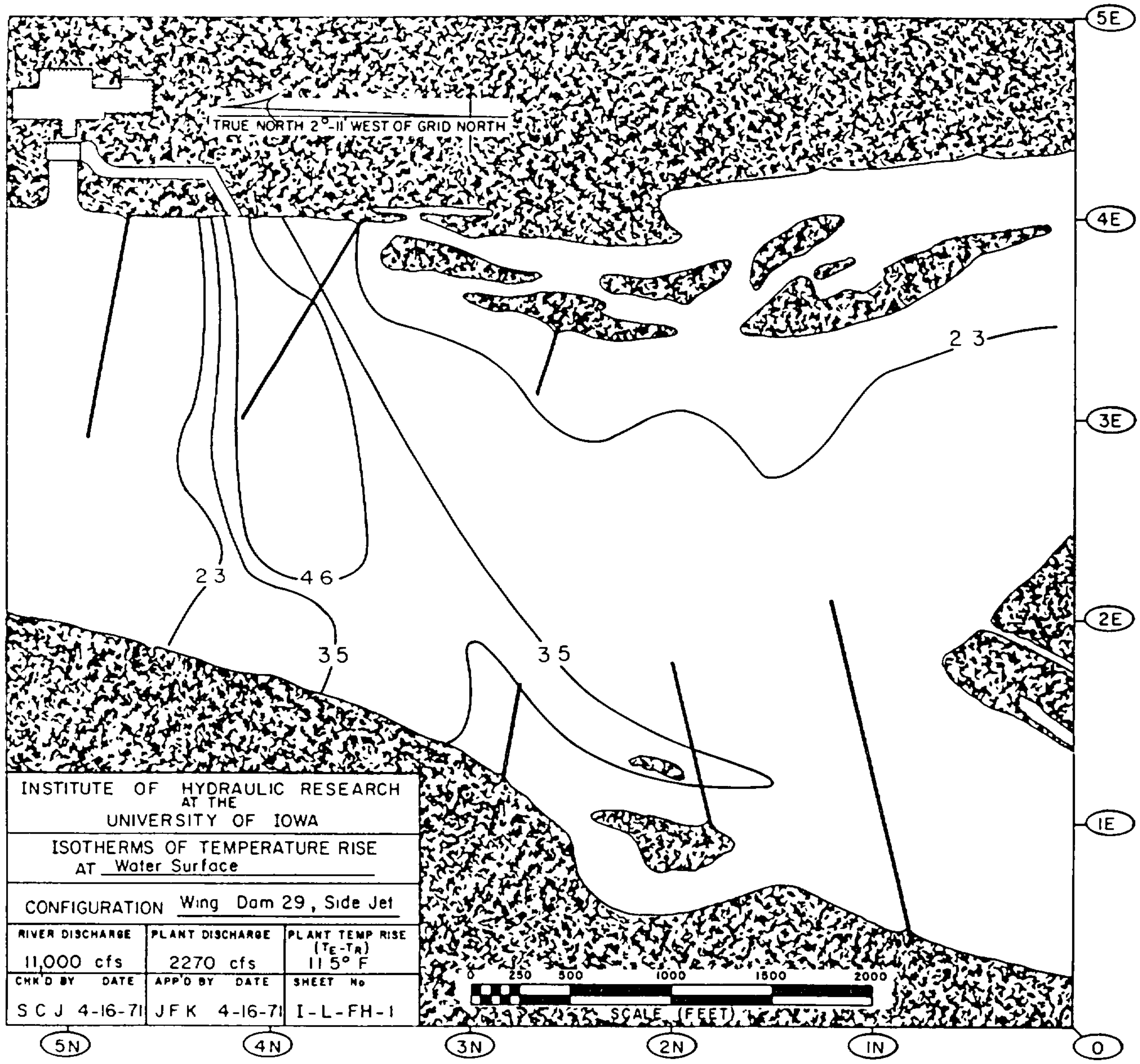


FIGURE 11a(4) TEMPERATURE-RISE CONTOURS AT WATER SURFACE FOR INTERIM SIDE JET

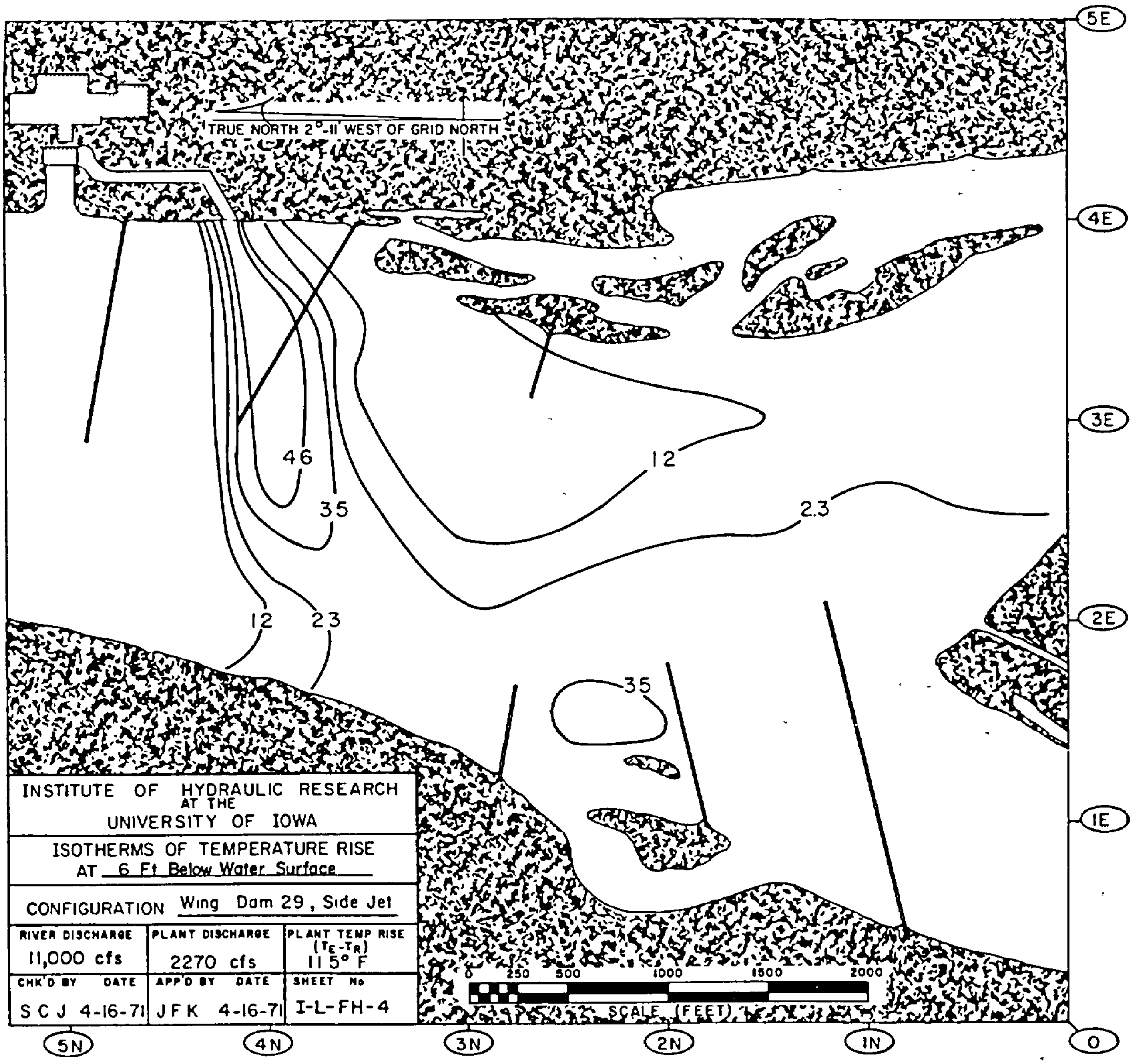


FIGURE 11b(4) TEMPERATURE-RISE CONTOURS AT 6 FT BELOW WATER-SURFACE FOR INTERIM SIDE JET

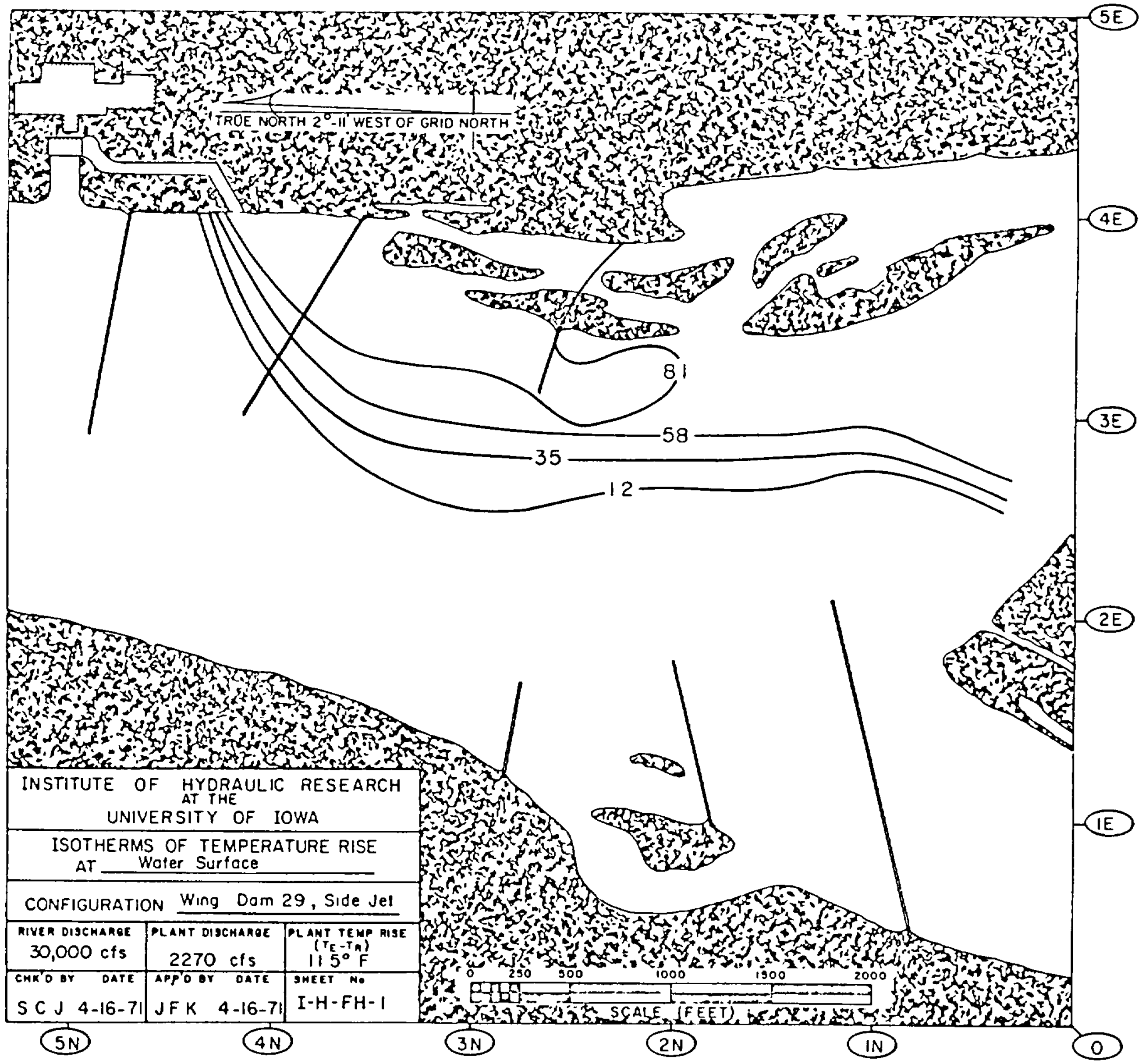


FIGURE 11c[4] TEMPERATURE-RISE CONTOURS AT WATER SURFACE FOR INTERIM SIDE JET

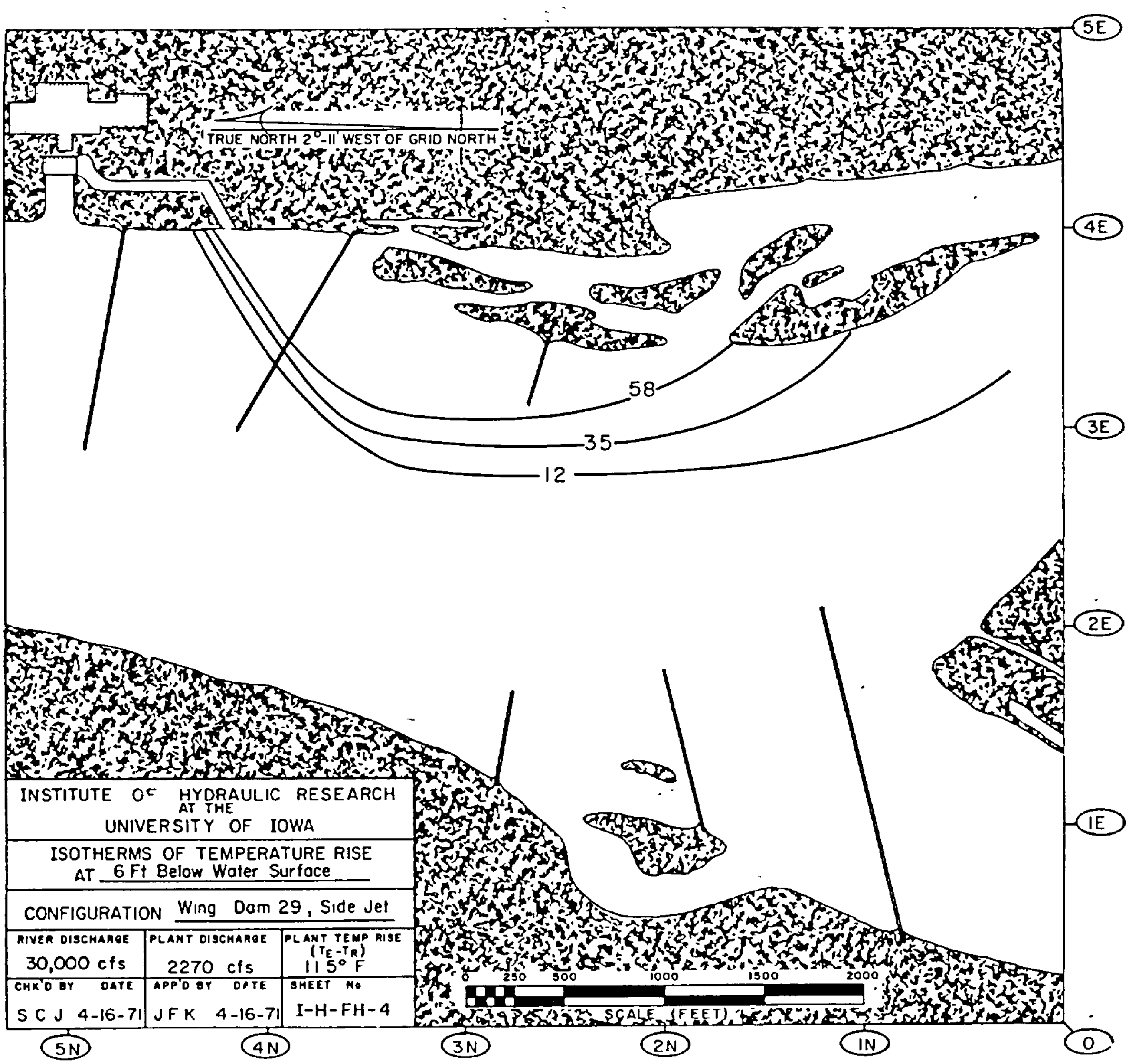


FIGURE 11d(4) TEMPERATURE-RISE CONTOURS AT 6 FT BELOW WATER SURFACE FOR INTERIM SIDE JET power is expected to be 2°F above ambient or less at the lowest flow of record since 1938 (11,000 cfs) and less than 0.5°F above ambient at average flow (46,000 cfs) (see Figure 12).

As can be noted on Figure 12 the temperature rise of the river with a fully mixed flow would be about 4.8°F at the lowest flow of record since 1938 (11,000 cfs), and would be about 4.0°F at the annual low 7-day flow once in ten years (13,200 cfs). The lower of these two river flows has occurred with a frequency of less than 0.1 percent since 1938 and the higher at a frequency of about 0.5 percent.[20] At an average flow of 46,800 cfs (frequency 50 percent) the temperature rise of the river would be 1°F. At a flow of 20,000 cfs the temperature rise would be 2°F. Flow of this latter magnitude or greater occurs 85 percent of the time.

Calculations were made by the staff to determine the heat loss rate of the river after a fully mixed state is achieved. The formulation used was based on the work of Edinger and Geyer.[21] River width, volumetric flow, water temperature and wind speed are significant parameters in this formulation. The following cooling characteristics in the lower part of Pool 14 can be estimated assuming a temperature rise of 3°F ambient, a river width of 2,150 ft., a wind velocity of 10 miles per hour and a river temperature of 85°F:

- about 93 percent of the time the river will be 3°F or less above ambient beyond the mixing zone.
- about 0.5 percent of the time, the point at which the river cools to 3°F above the ambient temperature will be approximately 10 miles downstream.
- less than 0.1% of the time, the point at which the river water returns to 3°F above the ambient temperature will be approximately 15 miles downstream.

The mixed river flow temperatures caused by operation of the station will influence the slough areas. This effect will be most pronounced for the flow-through sloughs where a low flow exists and least pronounced in quiescent sloughs. Since the major heat load to these areas is solar, the effect of the additional amount of heat from the station is expected to be small (that is, 3.5°F maximum temperature rise 90 percent of the time compared to as much as 18°F temperature increase due to solar heat, see Figure 12 and reference 22).

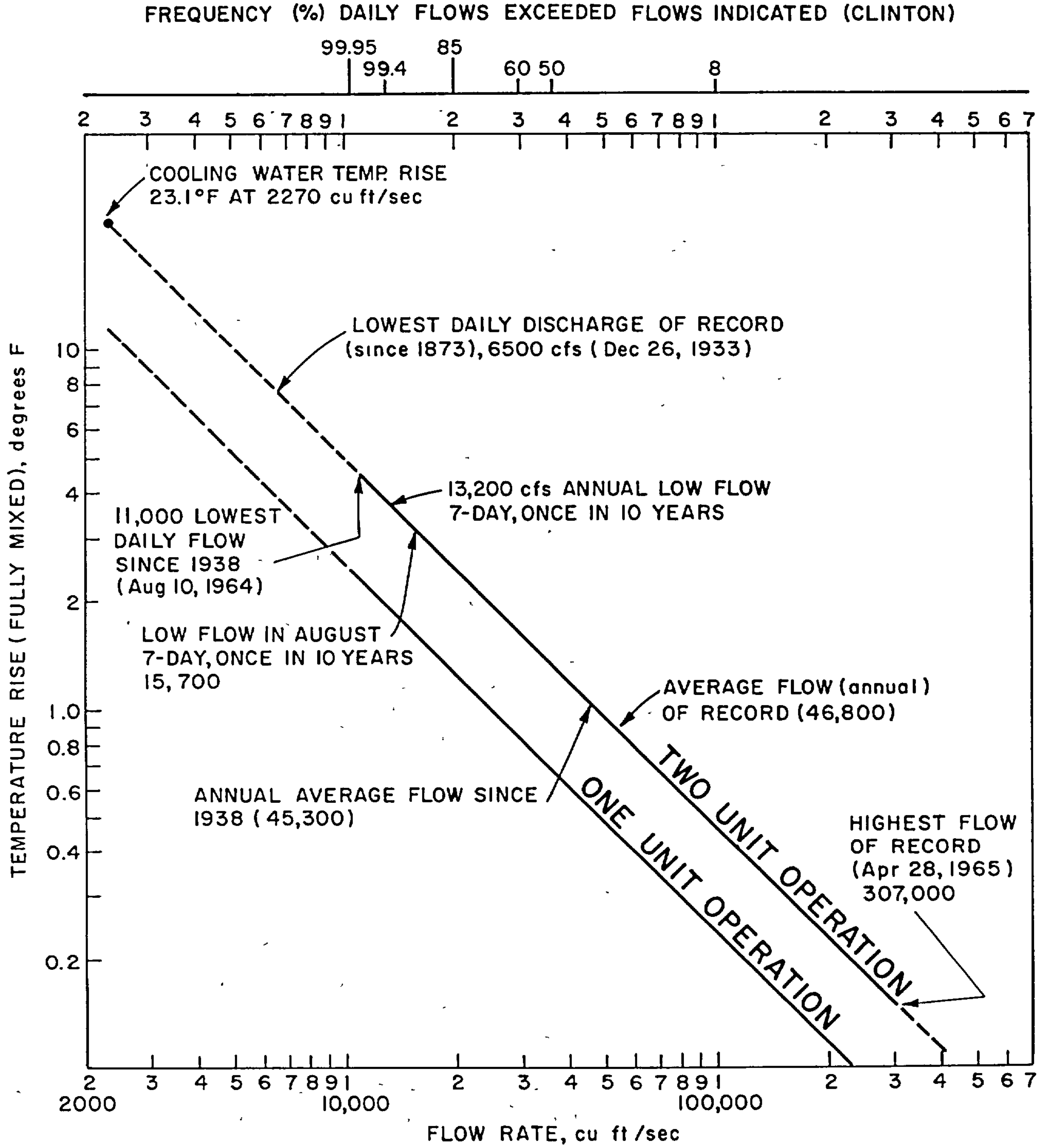


Figure 12. Temperature Rise of the River as a Function of River Flow.

The applicants will be required to report on a semi-annual basis the results of the non-radiological environmental monitoring. There will be a separate report on the operation of the side-jet. This includes any short term reversible environmental effects and a discussion of the measures to be taken to assist natural recovery from such effects.

(2) Diffuser-Pipe

The diffuser-pipe system started operation on August 2, 1972. This system will be used completely until the spray-canal is available. After the spray-canal is operable to accept the condenser discharge from both units, the diffuser-pipe system will be used for emergency purposes only as stated previously in Section III.

The system consists of a multiport discharge at the bottom of the main channel of the river. The diffuser-pipe extends across the main channel and lies below the 18 foot maximum depth needed for navigation (see also section IV B). No heated water is discharged to the shallow, off-channel portions of the river, since the lower velocity of the shallow does not provide effective dilution. Each of the 51 jets will be 29-in. in diameter and can be made smaller if desired. The jets will be in two groups with a 19.7-ft spacing (on centers) for one group and 39.3-ft spacing for the other group. The reference design of the diffuser system is illustrated in Figure 10. Mixing of the heated water with river water to give a temperature rise not exceeding 5°F is calculated to occur within 200 ft based on model tests.[3,4]

The diffuser-pipe system and model studies are described in greater detail in the applicants' environmental report.[4,19] Table 5 presents summary data of the diffuser model tests. Results of tests 10 and 11 and reproduced* as Figures 13a and through 13d.

As noted under the previous section discussion of Side Jet, Figure 12 shows the temperature rise with fully mixed flow for one or two unit operations. The discussions for mixed flow with the side jet are equally applicable for the diffuser. In fact, the mixed flow condition is more predictable since the diffuser induces rapid mixing and any higher temperature zones are rapidly dissipated. As indicated in the previous section, the applicants will be required to report semi-annually the results of the non-radiological monitoring program while the diffuser-pipe discharge is in operation.

*The temperature increases of 5.1 and 5.2°F shown in Figure 13c are within the limits of experimental accuracy of a completely mixed state which would be 4.8°F at all points on the figure.

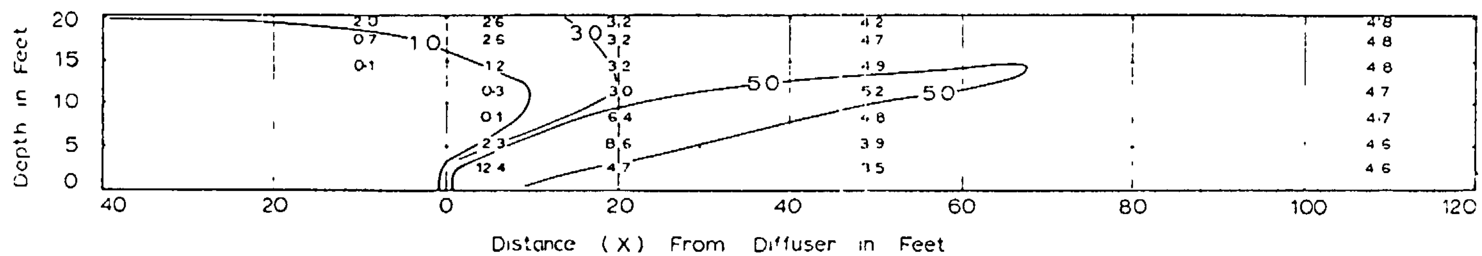
TABLE 5

SUMMARY OF TESTS IN TWO-DIMENSIONAL[18]
(SECTIONAL) DIFFUSER MODEL

Station cooling water discharge
Temperature rise = 23°F

Run	River Discharge, cfs	River Depth, ft	Jet Velocity fps	Port Spacing, ft	Port Angle (0),°	Approx. Upstream Length of Thermal Wedge, ft	Approx. Downstream Dist. to Full Mixing ft
1	11,000	20	10.0	14.2	30	(a)	80
2	11,000	15	10.0	14.2	30	(a)	80
3	11,000	20	10.0	14.2	15	(a)	80
4	11,000	20	10.0	14.2	20	250	80
5	13,500	20	10.0	14.2	20	(a)	80
6	35,800	20	10.0	14.2	20	0	120
7	11,000	20	10.0	30.0	20	50	120
8	11,000	8	7.4	8.0	20	170	50
9	11,000	20	10.0	39.33	20	(a)	180
10	11,000	20	10.0	19.67	20	75	110
11	11,000	25	10.0	19.67	20	300	110
12	11,000	10	9.1	39.33	20	200	90

(a) Not determined



42	44	43	40	37	42	44	46	4.6	50	51
49	5.2	5.0	46	46	47	51	52	5.4	58	59
48	5.2	49	44	47	49	48	5.1	5.3	5.7	58
45	51	48	43	47	52	49	50	52	52	52
40	44	42	39	43	48	48	48	51	54	55
42	42	43	42	37	39	38	42	45	49	52
44	42	42	41	36	35	36	4.1	46	48	51

X = 47 2'

45	45	46	48	48	48	49	49	49	48	48
45	46	46	47	48	48	49	49	49	49	49
46	46	46	47	47	48	48	48	49	49	49
46	45	46	46	45	47	47	48	48	48	48
45	45	44	45	46	47	47	48	47	48	48
[illegible]	44	44	45	45	46	47	48	48	49	49
45	45	44	44	45	46	47	47	48	49	49

X = 109'

NOTE Thermal Wedge Extends to 75 ft Upstream of the Diffuser

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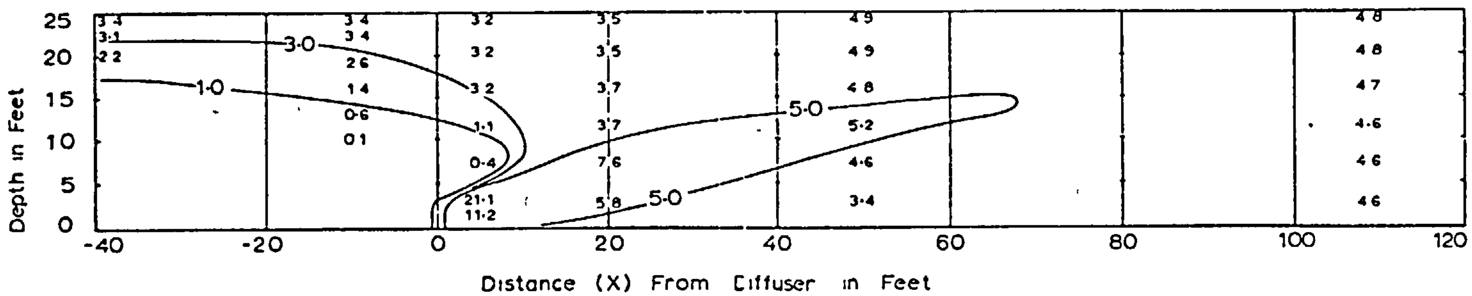
ISOTHERMS (T - Tr) °F | JET VELOCITY 10.0 fps

PLANT TEMPERATURE 23°F

PLANT DISCHARGE 2,270 cfs

10

FIGURE 13a(4) LONGITUDINAL AND CROSS-SECTIONAL TEMPERATURE-RISE DISTRIBUTION



4 9	5.0	5 0	4 9	4 9	4 9	4 9	4 9	4 9	4 9	4 9
4 9	5.0	5 0	4 9	4 9	4.9	4 9	4 9	4 9	4 9	4 9
4.7	5.2	5 1	4 6	4 6	4 8	4.7	4.7	4.9	5.0	5 0
4.6	5.2	5 0	4 6	4 8	5 2	5.0	5 1	5.2	5.3	5.1
4.3	4.4	4 6	4 2	4 1	4 6	4 5	4.6	4 8	4 8	4.9
3.7	3.4	3 2	3.0	3 2	3 4	3 9	4 3	4.7	4.7	4 8

X = 472'

4 7	4 6	4 6	4 7	4 7	4 8	4 8	4 8	4 8	4 7	4 6
4 7	4 6	4 6	4.7	4 7	4 8	4 8	4 8	4.8	4.7	4 8
4 7	4.7	4 7	4.7	4 7	4.7	4 7	4 8	4 7	4 7	4 8
4 8	4.8	4 6	4.6	4 6	4 6	4 5	4 6	4 6	4 8	4 8
4 7	4.6	4 6	4.6	4 6	4 6	4 6	4 6	4 6	4 7	4.7
4.6	4 6	4 6	4 6	4 6	4 6	4 5	4 6	4 6	4.6	4 6

X = 109'

NOTE: Thermal Wedge Extends to 300 ft Upstream of the Diffuser

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ISOTHERMS (T - TR) °F	RIVER DISCHARGE 11,000 cfs	PLANT DISCHARGE 2,270 cfs	PLANT TEMP RISE 23°F	RUN No. 11
JET VELOCITY 100 fps	PORT SPACING 19'-8"	CHK'D	APP'D	

FIGURE 13b(4) LONGITUDINAL AND CROSS-SECTIONAL TEMPERATURE-RISE DISTRIBUTION

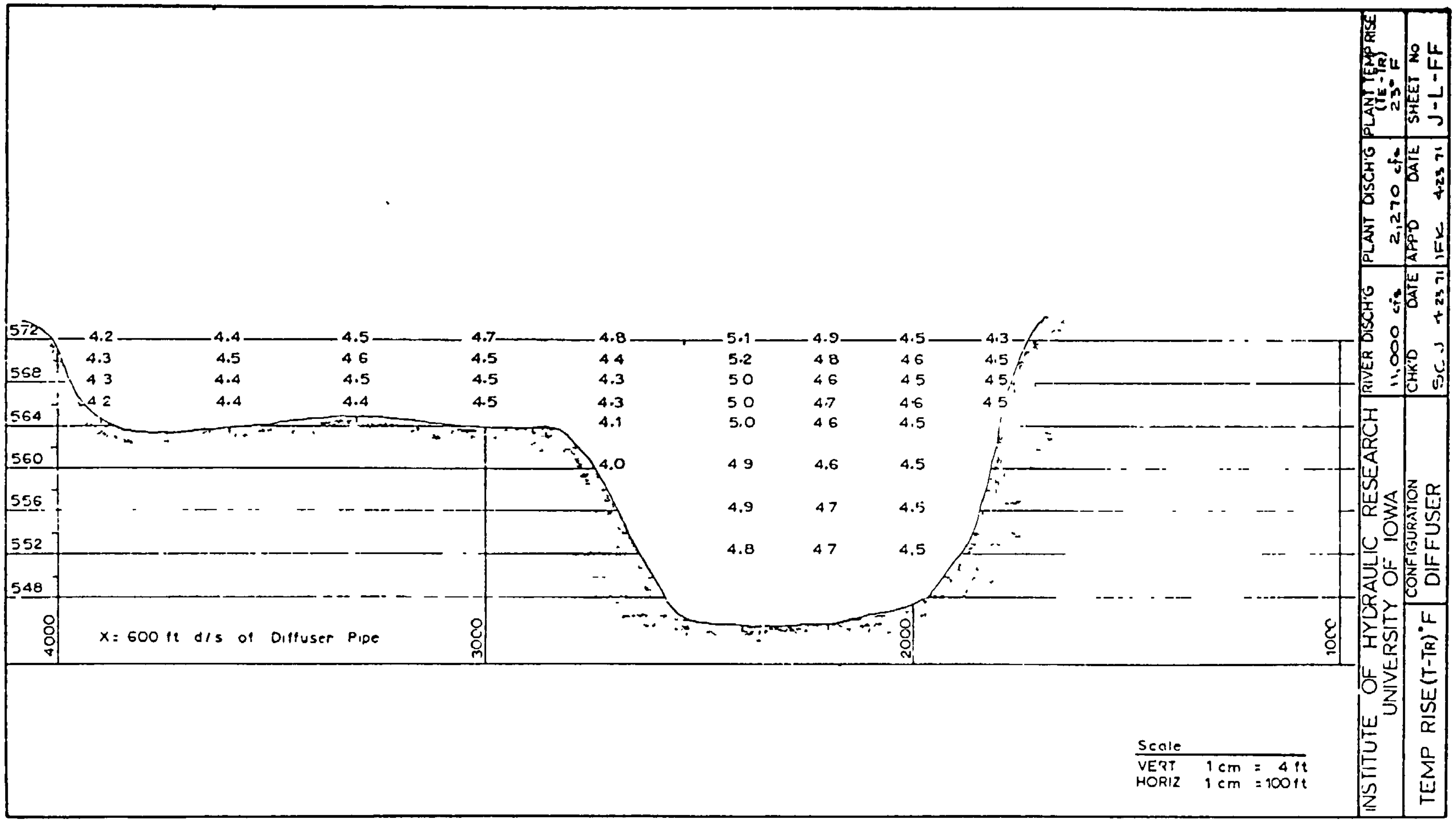

FIGURE 13c(4) CROSS-SECTIONAL TEMPERATURE-RISE DISTRIBUTION
(Q_R = 11,000 cfs)

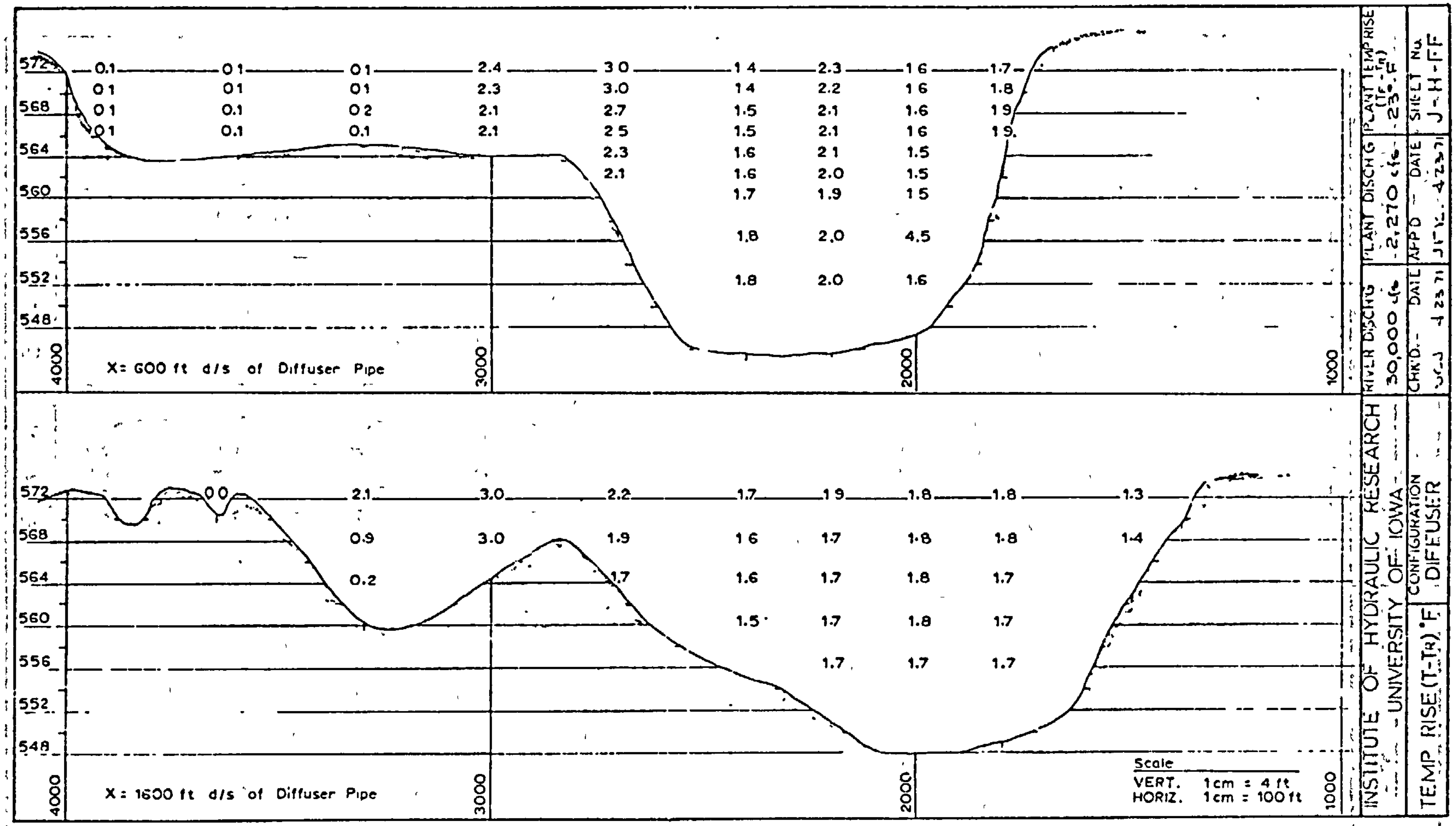

FIGURE 13d(4) CROSS-SECTIONAL TEMPERATURE-RISE DISTRIBUTION
(Q_R = 30,000 cfs)

(3) Spray Canal

The spray canal is a closed-cycle cooling system, the basic layout of which is shown in Figure 4a. As stated previously, the applicants have scheduled the canal to be operable for one unit by May 1974 and for two units by May, 1975.

The spray canal as discussed is described in the applicants' Environmental Impact Report (November 1971, Supplemental Information to the Environmental Report),[4] Supplement 4, December 30, 1971,[8] and Supplement 5, April 24, 1972.[25] The heated water leaving the condensers is pumped into the canal. The canal has floating spray modules which pump water flowing in the canal through spray nozzles and the spray falls back into the canal. The warm water is thus brought into direct contact with the air with a resultant transfer of heat from the water to the atmosphere via sensible and latent heat transfer mechanisms. The cold water flows from the canal back to the screen house for recirculation through the condensers.

To account for evaporative and drift losses from the canal and to limit the residual buildup of solids and chemicals within the canal, the system will be provided with make-up water and blowdown facilities; no final description of these facilities has been provided by the applicants. However, the estimate of the canal and its operating characteristics are as follows:

Number of Sprays: 300 modules of one pump and four spray nozzles each of Dresden type or similar;

Length of Canal: 13,000 to 14,000 feet;

Width of Canal: 170 to 200 feet;

Area of Canal Proper: Approximately 60 acres

Evaporation of Cooling Water to Air: Less than 50 cfs, for full heat dissipation;

Blowdown to River Via Diffuser: Approximately 50 cfs for blowdown (purge) on an annual average basis, with occasional rates to 125 cfs for short periods;

Makeup from River: Sum of evaporation plus drift plus blowdown plus ground leakage of water in the canal, as discussed below. The makeup requirement is expected to be less than 120 cfs on the average.

The leakage rate for the canal system was earlier estimated at 3 to 5% (p. 13, Supplement 4[8] of the ER). This rate applied to the 2270 cfs flow would lead to higher makeup requirements than indicated above. However, the applicants have not yet finalized the sealing design, but are studying both the effects of leakage and alternative methods of canal sealing with the aim of providing minimum leakage.

Studies of the performance of the spray system are continuing at Dresden and elsewhere. Studies specifically of meteorological effects are described in Section V.

The economic considerations involved in the installation of the two-unit spray canal has been stated by the applicants[25] as follows. The initial investments for the spray system is estimated to be $30.2 million. This cost includes the sealing of the canal to prevent water leakage into the generally permeable soils of the site. Net power generation losses (due to increased pumping requirements and to capability loss from higher condenser temperature) are estimated at $13.2 million in equivalent investment dollars. Additional operation and maintenance costs are estimated at $3.9 million. The total of the above items is $47.3 million in equivalent investment dollars.

2. Radioactive Waste

During the operation of the station, radioactive material will be produced by fission and by neutron activation of metals and material in the reactor system. Small amounts of gaseous and liquid radioactive wastes may enter the effluent streams, which are monitored and processed within the station to minimize the radioactive nuclides that will be released to the atmosphere and the Mississippi River under controlled conditions. The radioactivity released during operation of the station at full power will be in accordance with the Commission's regulations, as set forth in 10 CFR Part 20 and 10 CFR Part 50.

The waste treatment and handling systems described in the following paragraphs are common to both Units 1 and 2 and are designed to collect and process the gaseous, liquid and solid waste which might contain radioactive materials. The limits established in 10 CFR Part 20 apply to the combined releases from Units 1 and 2.

The waste handling and treatment systems currently installed at the station are discussed in detail in the Final Safety Analysis Report,[14] in the applicants' Environmental Report[13] and the Supplements[15,16,17]. The proposed modifications to the gaseous waste treatment system are discussed in Supplement #1.[15] The proposed changes to the liquid waste treatment system are outlined in Chapter 5, Supplement #2[16]. The modifications to these systems were not considered when the initial effluent levels were estimated (see Section V D), since these changes will not be completed until December 1, 1973.[7] The estimated effectiveness of these modifications are given as factors of reduction in the following sections, and future emissions will, of course, be limited by AEC regulations as indicated. In order to achieve lowest practicable radwaste discharge levels until the augmented system becomes operational, it will be necessary to employ all available components of the present system and to route waste streams so as to optimize treatment. The Commission's Regulation 10 CFR 50.36a requires that the equipment installed in the radioactive waste treatment systems be maintained and used to control the releases of radioactive effluents as defined by the approved Technical Specifications which are a part of any license issued.

a. Gaseous Waste

During full power operation of the station, radioactive materials released to the atmosphere in gaseous effluents (which arise from the non-condensible gases left after steam condensation from the turbine generator) include fission product noble gases (krypton and xenon), activated argon and nitrogen, halogens (mostly iodines), tritium contained in water vapor, and particulate material including both fission products and activated corrosion products. Fission products are released to the coolant and some may be carried to the turbine by the steam if defects occur in the fuel clad or if uranium is present as an impurity in or on the clad itself.

The major source of gaseous radioactivity during normal station operation will be the off-gas from the steam condenser air ejectors. Other sources include primary containment purge, the gland seal off-gas system and the reactor building, radwaste building, and the turbine building exhaust systems.

Prior to release, the off-gases from the main condenser air ejectors will be delayed for a minimum of 30 minutes in a holdup pipe (to allow decay of activity of short-lived radioactive noble gases) and filtered through high efficiency particulate filters, and then released to the environment through a 310 foot-high main station chimney. The radioactive materials released through the main condenser air ejector represents greater than 99 percent of the activity due to gaseous effluents. Additional sources of gaseous waste are discussed below.

The reactor building exhaust system removes air from the reactor building ventilation system and from the drywell and torus purge exhaust system. This air will normally contain low concentrations of activity and will be discharged to the reactor building vent stack. The system is so arranged that the exhaust air is automatically directed by monitors in the stack to the standby gas treatment system (high efficiency particulate filters and charcoal adsorbers in series) for release through the main station chimney if the activity is above a predetermined level. The primary containment is normally a sealed volume. However, during periods of refueling, maintenance, or whenever primary containment access is required, the potential exists for the release of airborne radioactivity to the environment. In those cases air is removed through the drywell and torus purge system (pre-filters and high efficiency particulate filters) and discharged to the reactor building vent stack.

The turbine building exhaust system, which is expected to contain low concentrations of activity, primarily from steam system leakage, draws air from the east and west portions of the turbine building and is discharged to the atmosphere through the main station chimney which is continuously monitored. In addition, hood exhausts are provided for each solid waste filling station. Separate exhausts are also provided for drum filling hoppers and centrifuge. The air exhausted is filtered prior to being discharged to the radwaste building exhaust system.

The steam/air exhaust from the turbine sealing system will pass through a gland seal condenser where the steam is condensed and the non-condensibles are exhausted to the gland seal holdup line. The small quantity of radioactive gases released by way of the gland seal off-gas system is delayed for about 2 minutes to allow decay of the major activation gases (N-16 and O-19) prior to release through the main station chimney.

On the basis of operating experience[23] with reactors of similar design, it is expected that the off-gas system described above will keep releases of gaseous radioactive wastes well within the limit specified in 10 CFR Part 20. In order to reduce these levels to the lowest level practicable during extended power operation, the Commission has requested the applicants to install additional gaseous holdup equipment. A modification to the present system will provide recombination of the hydrogen and oxygen formed in the reactor coolant, a condenser to remove much of the water vapor, and an 8-bed charcoal delay system to provide additional retention time for the krypton and xenon and to provide additional adsorption of iodines and particulates. The modified system is expected to be operational about December 1, 1973. Based on our evaluation, we anticipate that the proposed modification will result in a reduction of offgas activity (curies of noble gases) by a factor of approximately 15 relative to a 30-minute holdup system and that total iodine from all sources will be reduced to less than 0.5 curies/year/unit.

On the basis of our evaluation and experience at other operating plants with similar gaseous waste treatment systems, activity releases prior to the installation of the modified treatment system are estimated at 2,055,000 curies/year per unit, primarily noble gases (as shown in Table 6a). The releases of iodine-131 are estimated at 18 curies/year per unit. Table 6b shows the estimated releases of radioactive materials in gaseous effluent after the modified system has been installed. The principal assumptions used in our evaluation are shown in Table 6c.

b. Liquid Waste

Liquid wastes which are potentially radioactive are routinely collected and processed through the floor drain, chemical or miscellaneous radwaste systems. Liquid effluents from these systems can be released to the environment through only one pathway, the liquid radwaste discharge header which ultimately discharges liquids to the Mississippi River after dilution in the discharge canal.

The applicants plan to recycle water as a fundamental plant process. Both the condensate-demineralizer system and the reactor-water cleanup system are designed to assure requisite purity and activity levels to permit recycling of most of the plant water that contains radionuclides. Recycling is also provided for about 60 percent of the water that goes through the liquid-radwaste system.

During normal operation, water from the primary reactor system resulting from equipment leakages will be filtered and demineralized and placed in the condensate storage tank for reuse in the reactor. Water from the waste sample tank can be released after sampling and analyses at a controlled rate into the Mississippi River in the event of excess water inventory or in the event that water does not meet feedwater chemical quality requirements. The condensate from the future augmented off-gas system will also be placed in condensate storage. Liquid radioactive wastes from drain sumps, drain tanks, and floor drains are collected, filtered and temporarily stored prior to discharge.

TABLE 6a

ESTIMATED RELEASES OF RADIOACTIVE MATERIALS IN GASEOUS
EFFLUENT FROM QUAD CITIES, UNIT 1 AND 2
(Power Level 2511 MWt per unit)

Curies/Year/Unit

Nuclide	Reactor Building	Turbine Building	Gland Seal	Mechanical Vacuum Pump	Condenser Air Ejector (30 Min. delay)	Total
Kr-83m	-	7	65	-	53,300	53,400
Kr-85m	-	12	105	-	97,900	98,000
Kr-85	-	-	1	-	550	550
Kr-87	-	35	310	-	240,000	240,350
Kr-88	-	40	340	-	302,400	302,800
Kr-89	-	120	735	-	1,550	2,400
Xe-131m	-	-	-	-	480	480
Xe-133m	-	1	7	-	6,680	6,680
Xe-133	-	20	190	1,445	188,000	188,200
Xe-135m	-	60	490	-	140,700	141,250
Xe-135	-	60	535	215	516,100	516,700
Xe-137	-	210	1,360	-	8,035	9,600
Xe-138	-	190	1,550	-	490,200	492,000
TOTAL		755	5,700	1,660	2,046,000	2,055,000
I-131	0.009	0.41	0.036	-	18	18
I-133	0.03	1.9	0.16	-	81	83

TABLE 6b

ESTIMATED RELEASE OF RADIOACTIVE MATERIALS IN GASEOUS
EFFLUENT FROM QUAD CITIES, UNIT 1 AND 2
AUGMENTED SYSTEM
(Power Level 2511 MWt per unit)

Curies/Year/Unit

Nuclide	Reactor Building	Turbine Building	Gland Seal	Mechanical Vacuum Pump	Condenser* Air Ejector	Total
Kr-83m	-	7	65	-	1,110	1,180
Kr-85m	-	12	105	-	19,100	19,200
Kr-85	-	-	1	-	550	550
Kr-87	-	35	310	-	820	1,170
Kr-88	-	40	340	-	23,120	23,500
Kr-89	-	120	735	-	-	860
Xe-131m	-	-	-	-	365	365
Xe-133m	-	1	7	-	1,640	1,650
Xe-133	-	20	190	1,445	102,800	103,000
Xe-135m	-	60	490	-	-	550
Xe-135	-	60	535	215	130	725
Xe-137	-	210	1,360	-	-	1,570
Xe-138	-	190	1,550	-	-	1,740
TOTAL		760	5,700	1,660	150,000	159,000
I-131	.009	0.41	0.036	-	-	0.46
I-133	.03	1.9	0.16	-	-	2.1

*Recombiner and Charcoal Delay System

TABLE 6c

PRINCIPAL ASSUMPTIONS AND CONDITIONS USED IN ESTIMATING RELEASES OF RADIOACTIVITY IN EFFLUENTS FROM QUAD CITIES, UNITS 1 AND 2

Thermal Power, Megawatts per unit	2511
Plant Factor	0.8
Steam Flow, lb/hr	14.9×10^6
Cleanup Demineralizer Flow, lb/hr	1.33×10^5
Leaks:	
Turbine Building, lb/hr	1700
Gland Seal, lb/hr	1.49×10^4
Reactor Building, lb/hr	480
Mass of liquid, lb.	3.3×10^6
Mass of steam, lb.	4.23×10^4
Partition Coefficients (Iodine):	
Primary Coolant (steam/liquid)	.012
Air Ejector	.005
Reactor Building	.001
Turbine Building	1
Gland Seal	1
Charcoal Delay System, Holdup Time:	
Xenon, days	4.4
Krypton, hrs.	5.9

In passing through the various tanks of the radioactive waste control system, contaminated liquids are subjected to a holdup time which varies from approximately 1/2 to 1 day to permit decay of the numerous short half-life radionuclides. After these wastes are sampled and analyzed, they will normally be released to the discharge canal or reused in the plant systems. Chemical wastes of high conductivity variable activity wastes are sampled, neutralized, and either filtered and released to the discharge canal or solidified and packaged as solid waste. Detergent waste collected in the laundry drain tanks will be generally low in activity and will be processed through filters and discharged to the canal with dilution.

The estimated quantities of liquid effluents are based on releasing to the circulating water discharge canal at a controlled rate small quantities of concentrated liquid wastes from the chemical waste monitor tanks, excess water from the condensate recycle storage tank, and liquids from miscellaneous waste collection system.

The applicants state[18] that a "maximum recycle" liquid radwaste system will be installed which will reduce discharges to the Mississippi River from 26 curies per year to less than 1.2 curies per year after December 1, 1973. The basic modification will permit recycling of most of the effluents from the floor drain subsystem. This will be achieved by the addition of two deep bed demineralizers identical to those used in the present clean waste collector subsystem. A floor drain surge tank will also be added to serve as a contingency collector. The chemical waste system will be modified by the addition of a chemical waste sample tank. This addition will provide a contingency tank to make certain that discharges are as low as practicable.

Spent resins from the radwaste demineralizer are not regenerated but are disposed of as solid radwaste. The use of non-regenerative demineralizers leads to smaller volumes of liquid waste and thus less addition of activity to the environment, than if a regenerating resin system were used in the same manner. The modified system appears to be capable of reducing discharge of radioactive materials to the Mississippi River to levels which may be considered as low as practicable. Until the modifications are completed, experience at other operating plants[23] with similar floor drain systems indicates that we should anticipate activity released at the rate of about 15 curies/year from each unit or a total of about 30 curies per year from the station. Tritium releases are estimated at 20 curies/year per unit. Table 7 lists the principal isotopes, as determined by the staff, and the expected annual quantities (in curies) of each

TABLE 7

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN LIQUID EFFLUENT FROM THE QUAD-CITIES STATION

(100% Power)

Radionuclide	Curies Per Year Per Unit	
Cr-51	0.52	
Mn-54	0.065	
Fe-55	0.15	
Co-58	3.6	
Co-60	1.8	
Sr-89	1.7	
Sr-90	0.20	
Zr-95	3.9	
I-131	0.31	
I-133	0.10	
Cs-134	0.57	
Cs-137	1.5	
Ba-140	0.57	
Ce-144	0.002	
Total	15	curies/unit
H-3	20	curies/unit

that are expected to be released in liquid effluent. Principal assumptions and conditions used in estimating releases of radioactivity in effluents are given in Table 6c.

c. Solid Waste

Cleanup and condensate system filter-demineralizer sludges are collected in a phase-separator where excess backwash water is removed by decanting. The sludges, which consist of filter aid, spent resins, activated corrosion products, fission products, and other insoluble materials, are accumulated for radioactive decay. These wastes are dewatered in a centrifuge and mixed with concrete in drums for shipment offsite to a licensed burial ground. Maintenance wastes, such as contaminated clothing and tools, are compressed into bales to reduce volume and are packaged as solid waste. Annual spent resin quantities of solid waste to be shipped offsite are estimated by the applicant at 842 drums containing 18,820 curies of activity.[16] All solid waste will be packaged and shipped to a licensed burial ground in accordance with AEC and DOT regulations.

3. Chemical and Sanitary Wastes

Plant effluents carry certain chemicals added to cooling-water and process-water streams for control of marine fouling, for regeneration of water-purifying demineralizers, and for maintenance of water quality, both in-plant and as waste streams. All the principal chemicals (except chlorinating agents) that will be released from the plant via cooling-water blowdown discharge to the river are listed in Table 8. Because of its importance and particular chemical nature, the chlorinating agents are discussed separately below.

In Table 8 the principal waste water streams bearing chemicals are identified, based on detailed information on waste water quality presented in Exhibit F of the applicants' responses (June 15, 1972)[28] to comments of federal agencies and others on the Draft Detailed Statement of March 6, 1972. The main result of Table 8 is to show that the average concentration of chemicals in the combined discharge to the river is only a fraction of the same chemical species naturally present in river water. Concentrations are shown both for the use of cooling-water recycle in closed-cycle operation (illustrated as 100 cfs outfall) and for non-recycle operation (2270 cfs outfall). Because of the intermittent addition of chemicals in the batch treatments, the open-cycle (once-through) case has peak concentrations higher than average, as shown in Table 8. Such peak concentrations do not occur when batch discharges are made to the circulating water system in closed-cycle operation. These concentrations of chemicals are only a small fraction of any limits established by the Illinois Pollution Control Board.

TABLE 8

PRINCIPAL CHEMICAL ADDITIONS TO LIQUID DISCHARGES
(ALL ADDITIONS OTHER THAN FOR CHLORINATION)

Chemical Effluent	Expected Average Daily Addition (lb)	Expected Average Discharge Volume (gal)	Average Flow Duration	Average Discharge Frequency	Yearly Average Concentration in discharge (mg/liter) in 100 cfs outfall	Yearly Average Concentration in discharge (mg/liter) in 2270 cfs outfall	Peak Concentration in 2270 cfs outfall (mg/liter
Well-water minerals and sodium sulfate from demineralizer regeneration.	390	5700 (batch)	2.5 hr.	1 per day	0.72	0.03	∿ 0.3
Dissolved and suspended solids in filter backwash from demineralizer.	34	6000 (batch)	30 min.	3 per day	0.063	0.0027	∿ 0.04
Sodium sulfite and phosphate in heating boiler blowdown.	2	560 (batch)	5.6 hr.	1 per week	0.0037	1.8×10^{-4}	∿ 0.005
Sodium sulfate in radwaste plant discharge.	1.8	20,000 (batch)	8.3 hr.	50 per month	0.0033	1.6×10^{-4}	∿ 3×10^{-4}
Dissolved solids in sewage treatment plant discharge.	49	Continuous	Continuous	10,000 gal/day	0.091	0.004	∿ 0.008

Sodium hypochlorite solution is added to cooling water streams to minimize fouling of piping by bacteria and other organisms. Present practice is to add the 15 percent hypochlorite solution in short periods as defined by the schedule of maximum addition rates given below:

Item	Water Flow Rate	Maximum Input of Sodium Hypochlorite	
Condenser cooling water	2100 cfs continuous	10 gal/min for 12 ten-minute periods per day	1460 lb/day
Plant service water	134 cfs continuous (170 with seventh pump operating)	10 gal/min for 2 twenty-minute period per day	490 lb/day
Residual heat-removal service water	17.8 cfs intermittent for 2 hr, once per month	0.1 gal/min for 1 hr per month	0.24 lb/day (average)

The above maximum schedules for addition of hypochlorite do not give effluent amounts, because they are subject to reductions by effluent controls presently established in the Technical Specifications for the plant. The water flow in each half unit is about 565 cfs. The concentration of residual free chlorine at the exit of the half-unit (the water box at the condenser mid-point) is not to exceed one part per million (1 mg/liter). This water is subsequently diluted in the circulating water system before being discharged into the discharge bay. The Technical Specifications require that the total free and residual chlorine in the discharge bay be $\leq$ 0.1 ppm. It should be noted that this specification was made for once-through cooling and will be revised for closed-cycle operation.

The concentration of chlorine (from sodium hypochlorite) in the cooling water of the condenser half being treated is calculated by the staff from the applicants' procedures to be 3.7 ppm. The quantity was chosen by experience to yield a "typical" value of about 0.5 ppm (range 0.2 to 0.7) "free chlorine"* after mixing with the unchlorinated

* The useful chlorine is present in the forms of the hypochlorite ion and hypochlorous acid, with the relative quantities determined by the pH of the water (1:1 at pH 7.5). The concentration of molecular chlorine in water that would have the same chlorine oxidizing capacity as is present in the OCl -- and HOCl is called the "free chlorine" level. The 1 ppm free-chlorine half-condenser effluent will contain 0.5 ppm Cl in the form of OCl -- or HOCl, since in these forms the chlorine has twice the oxidizing capacity per gram as elemental chlorine (valence changes from 1 to -1 during reaction versus the change from 0 to -1).

half-condenser stream.[15] The rate of addition will be modified in the light of experience with this station to maintain the above level of free chlorine.

In normal operation, the water from the condenser being treated will be diluted 2 to 1 upon mixing with the output of the other condenser, and will then flow into the discharge system. Typically, a substantial reduction in residual chlorine content can be expected to occur prior to discharge due to the reaction of chlorine with oxidizable material in the unchlorinated water. This reduction might be variable with time and with chlorine levels.

In addition to reacting with the substances comprising the chlorine demand,* free chlorine also reacts readily (at the river water pH) with any dissolved ammonia present to form chloramine. Typical river water levels of ammonia nitrogen (ca. 0.2 ppm) are stoichiometrically equivalent to 0.5 ppm chlorine in hypochlorous acid (or 1.0 ppm free chlorine); this is an excess above the quantity required to react with the 0.25 ppm diluted free chlorine present at the beginning of the discharge canal. The extent of the reaction will largely depend upon the relative concentrations of ammonia and free chlorine, since the equilibrium constant for the reaction between these substances favors essentially complete conversion to monochloramine at the river pH. The higher chloramines are reportedly not stable.[5,6] Any chloramine formed will then react with additional chlorine demand constituents. Since this reaction is less than that reducing the free chlorine, quantitative estimation of the degree to which all residual chlorine (the sum of free chlorine and combined chlorine) will have dissipated before discharge to the river is difficult.[27]

The importance of chloramine is that (a) its formation amounts to a removal of hypochlorite ion; (b) it also has a toxic potential, but only a fraction of that of hypochlorite ion; (c) it is chemically more stable than hypochlorite ion, but it (unlike the ion) can be lost by evaporation in natural waters and in evaporative cooling devices, such as a spray canal.[27]

These considerations suggest that the expected residual chlorine concentration in the condenser cooling water discharged to the river in once-through operation will be substantially less than 0.25 ppm in a flow of 2270 cfs. This concentration will be present, under

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* The chlorine demand of water is the elemental chlorine equivalent of the amount of free and combined chlorine that will react with oxidizable substances in the water. The substances that provide the chlorine demand vary from case to case, and the rates of oxidation of these substances vary over a considerable range.

normal full condenser flow, during three 40-minute periods per day. Dilution factors in the river will range from about 5 at a low river flow of 11,000 cfs to 20 at the average flow rate of 46,800 cfs. Thus, the expected residual chlorine concentrations in the river during periods of chlorination will be substantially less than either 0.04 ppm during minimum flow periods or 0.01 ppm during average flow.

An additional amount of chlorine will be added to the discharge bav in the service water discharge. The service water is chlorinated for two 20-minute periods per day, during which the residual chlorine in the 67 cfs (30,000 gpm) discharge from the service water unit will be about 0.5 ppm (again expected to vary in the range 0.2 to 0.7 ppm). When diluted in the condenser discharge bay at full operation, the service water contribution will be about 0.02 ppm during the chlorination periods, before natural decay as discussed above. The possible chlorine contribution to the river during a 20-minute period is about one-tenth that of the condenser chlorination.

The station has an operable sewage treatment plant which is designed for 15,000 gallons of sewage effluent per day (0.023 cfs). The plant is licensed by the State of Illinois and is under the supervision of a licensed sewage-treatment operator. It is currently operating at about 5000 gallons per day. The effluent is chlorinated according to state regulation.[9] Because of the comparatively low average flow rate of the sewage effluent (0.016 cfs), the residual free chlorine in this stream will be greatly diluted by plant blowdown.

The applicant's standard operating procedures and the Technical Specifications for the reference closed-cycle spray-canal operation have yet to be established. In this closed cycle operation the chlorine demand in the cooling water is expected to be smaller. This will reduce the requirement for addition of a chlorinating agent. This, together with the reduction in outfall from 2270 to about 100 cfs, will reduce the potential impact on river waters of residual chlorine.

4. Other Wastes

Nonradioactive solid waste consists of floating debris and fish removed from the intake forebay and screens and miscellaneous solid waste (garbage and trash) from other plant operations. The intake debris is taken from the station site to a burial site. Garbage and other solid wastes are removed to an officially designated sanitary land fill for this purpose. No refuse is buried on site.

The applicants estimated that the station's process heat boilers would consume 423 million cubic feet of natural gas per year and the diesel engines would consume 7500 gallons of fuel per year. Using fuel quality figures and combustion product composition given in the U.S.E.P.A. publication, "Compilation of Air Pollution Emission Factors (Revised) February 1972", the following total annual emissions were calculated.

SO_2	750	pounds per year
Particulates	7800	" " "
CO	550	" " "
NO_x	51,350	" " "
Hydrocarbons	17,450	" " "

E. <u>TRANSPORTATION OF FUEL AND RADIOACTIVE WASTE</u>

The nuclear fuel for each of the Quad-Cities reactors consists of 180 tons of uranium enriched to an average of 2.12 percent by weight with the isotope U-235. The fuel is in the form of sintered uranium oxide pellets encapsulated in Zircaloy-2 fuel rods. Each fuel element is made up of 49 fuel rods about 12 ft long and weighs about 490 pounds. Each year in normal operation about 25 percent of the fuel, or 180 fuel elements, is replaced in each reactor.

The applicants have indicated that cold nuclear fuel and solid active waste associated with the operation of the two reactors at the station will be transported by truck. Irradiated fuel will be transported to process plant by rail. Since the applicants have not identified, for the life of the station, the sources of the cold fuel, the fuel processing plants, or the waste burial grounds, we have estimated average distances for those shipments of 850 miles for cold fuel, 700 miles for irradiated fuel, and 500 miles for solid active waste. There will be no liquid active waste shipped from the station.

1. <u>Nonirradiated Fuel</u>

The applicants have indicated that the nonirradiated fuel will be shipped in AEC and DOT approved containers which hold two fuel elements per container. There are expected to be 4 or 5 truckload shipments of 32 assemblies per year per unit from a fabrication plant to the site. These annual shipments will take place during an estimated 2 week period.

2. <u>Irradiated Fuel</u>

Fuel elements removed from the reactor will have been irradiated to about 19,000 megawatt days per ton on the average; they will be unchanged in appearance and will contain some of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel elements will contain fission products and plutonium. As the radioactivity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after removal from the reactor. After removal from a reactor, the fuel elements are placed under water in a storage pool for cooling prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the applicants state that the irradiated fuel elements will be shipped in approved casks designed for transport by rail. The cask may weigh as much as 100 tons. The weight of the casks will be due principally to the radiation shielding materials - steel, lead, or uranium. The cask probably will contain water as the primary coolant. The applicants indicate that the irradiated fuel removed from the two reactors will require seven shipments by rail each year with 24 assemblies being shipped in each shipment.

3. Solid Radioactive Waste

The applicants estimate that the solid wastes generated by the two units will amount to approximately 2.3 drums per day (about 840 drums per year) of demineralizer resins fixed in concrete and about 10,000 cubic feet per year of packaged low level miscellaneous dry waste. Compressible wastes will be compacted.

The waste will be shipped in 55-gallon drums and other packages approved for transport of the activities involved. It is estimated that about 45 truckloads of drums and shielded containers will be required to ship the solid wastes to the burial grounds each year.

IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF PLANS AND SCHEDULES

The general features, size and location of the station site were fixed by the applicants in 1966. The site, which at that time was 404 acres, has now been increased to about 560 acres to accommodate the spray-canal. Construction has proceeded under applicable Federal, State and local approvals. Construction of both units is complete and initial operation has proceeded under a temporary license, first with side-jet cooling and then with diffuser-pipe cooling. Items remaining to be constructed are the spray canal and the modifications to the liquid and gaseous radwaste systems. Final design and construction details have not been furnished by the applicants for the spray-canal. The diffuser-pipe system was completed August 2, 1972. Installation of the spray-canal for one unit was estimated to require 28 months and to be completed by May 1974. The completion of the spray-canal for both units is scheduled to be completed by May 1975 in the agreement with the Attorney General of Illinois et al.[2]

Plans and installation procedures for the diffuser-pipe system were approved by the Corps of Engineers. The applicants in their June 3, 1971, revision to the application to the U. S. Army Corps of Engineers for Permit to Construct Diffuser-Pipe System at the station state they will remove an estimated 99,924 cu. yds. of unconsolidated alluvium and 504 cu. yds. of rock from the river bottom and will back fill with 75,300 cu. yds. of fill capped with 9,000 cu. yds. of rock rip-rap. The latest estimate of quantities of material excavated (furnished by the applicants on June 15, 1972)[3] for the installation of the diffuser discharge system is as follows:

Excavation		Backfill	
Unconsolidated			
Alluvium	177,690 cu. yd.	Pipe displacement	25,000 cu. yd.
Rock	9,000 cu. yd.	Alluvium	130,153 cu. yd.
Total	186,690 cu. yd.	Stone (from off site)	31,537 cu. yd
		Total	186,690 cu. yd.

The residual alluvium will be stored on the site. All dredged material will be deposited on the site within diked enclosures.

The full construction impact of the spray-canal will be reviewed when the applicants have furnished construction details such as amount of earth removed for installation, amount of backfill, and the ultimate disposition of excess earth. At this time, based on the nature of the activities involved, it appears unlikely that construction of the spray-canal will result in a serious adverse impact, especially because much of the excavated material will be used for dikes along the canal.

B. IMPACTS ON LAND, WATER, AND HUMAN RESOURCES

The site had, sometime in the past, been in agricultural-woodland usage. This 560 acres is, at least for the life of the station, out of agricultural usage since the applicants have no planned use for this land other than for electrical generation.

The site is graded to its final grade and all planned roads are completed. The additional major construction efforts involve the combiner carbon-bed system for the radwaste control of off-gases, the maximum recycle liquid-waste system and the construction of the spray-canal system. The combiner carbon-bed and the maximum recycle systems are in the design stage. However, they are expected to involve a relatively small investment of construction within the existing building area.

The diffuser-pipe system is submerged in the deep channel portion of the river. According to the installation drawings of Figure 5.8, p. 5.29 of the applicants' supplemental environmental report,[4] the top most parts of the diffuser-pipe are below the present bottom of the river, including the main-channel (deepest) portion. This shows that approximately 1000 ft of river width will be provided with a river depth of 18 ft or more above the pipe with respect to the flat pool elevation of 572.0 ft. This depth is greater than that specified for Corps of Engineers regulations. There was a temporary disturbance of benthic organisms and siltation of the river when the diffuser-pipe was moved into place. This disturbance involved a relatively small portion of the river bottom compared to the dredging the river has experienced in the past. The experience gained by dredging done by the Corps of Engineers[1] since 1960 has indicated that the benthic organisms can reestablish themselves from dredging projects.

The construction of the spray-canal will have a permanent effect on the environment. There will be relocation of the earth removed from the canal and the probable additional dislocation of small animals. It is likely that some of the trees on the east end of the property which were formerly undisturbed will be removed. According to the drawings (Figure 4a) a 300 ft width of trees will remain between the road and the station.

C. CONTROLS TO REDUCE OR LIMIT IMPACTS

The plant consists of a combination of aluminum-sided buildings with simple lines. The switchyard is similar in appearance to standard units. The view of the plant and switchyward is shielded from Route 84 by a grove of evergreen trees. The site will be maintained with cover vegetation similar to that in the surrounding area. All heavily used roads will be paved with asphalt to prevent dust formation.

During construction, temporary sanitary facilities (primarily chemical toilets) were installed and used by the construction forces at the site. These will be removed after construction is completed. A permanent sewage-disposal system, constructed to accommodate the station personnel, is provided at the site in conformance with applicable regulations of the State of Illinois Pollution Control Board and includes primary and secondary treatment. Debris from the various onsite excavations has been retained on the site in a spoil bank, and in addition, material dredged from the river was retained on site and not returned to the river. The temporary dock will be removed when construction needs no longer require it. These dredgings will be added to the site spoil bank. There are no plans to do other than grade and seed the spoil bank.

The excavated soil from the construction of the spray canal will be retained on the site. Some of this soil may be added to the existing soil bank but most of it is expected to be used to level the area and dike the canal.

V. ENVIRONMENTAL IMPACTS OF PLANT OPERATION

A. LAND USE

1. General

The operation of the station should have little or no adverse influence on the present use of the land surrounding the station. The 560 acre site itself had previously been used largely for agricultural purposes and for a few residences. The area north of the site is industrial.

The applicants will establish a nuclear information center in the administration building complex associated with the station. The center will consist of an exhibition room and a small auditorium. The information center will be established to minimize the necessity to tour visitors through the station. The center will have a tour director and a clerk to handle the public.

A visitors' parking lot has been established outside the security fence. Visitors will be required to pass through the security check point prior to entering the visitors' center.

No other site use is planned for the public. The applicants state that this is in compliance with the intent of AEC Safety Guide #17 "Protection Against Industrial Sabotage" and ANS 3.3 "Industrial Security Plans."

One road that formerly ran through the site has been closed. This road closely paralleled Illinois Route 84. The impact of the loss of the previous road is very small, since Route 84 is close and available.

A look at Figure 6, which shows the road in question, will indicate that Route 84 will serve the purpose of the closed road.

No established regional or local plans for land use are in conflict with the land use of the station. Testimony given at the Illinois Pollution Control Board hearing in June 1971[1] revealed there were no area plans for this site except that the general area is designated as industrial by the Bi-State Metropolitan Planning Commission. Statements were made at that hearing that a task force on a National Recreational Area on the Upper Mississippi River had no plans for the site, although some expansion of wildlife preserve areas on the Iowa side of the river was recommended.

A report prepared by the Illinois Department of Business and Economic Development[2] presented no specific plan for the area used for the station, although development of recreational areas is a prime concern of that report, and the Rock River Valley south and east of the site was cited as a key area for recreational development.

There are no plans for site landscaping. A large grove of trees already exists on both sides of Illinois Route 84 and the railway track, along the eastern edge of the site. (See Figure 9). The 300 foot width of these trees that will remain after the spray canal is constructed will separate the site from the road.

2. Meteorological Effects of Thermal Discharges

a. Side-jet

No serious atmospheric effects are expected from this mode of heat rejection based on many years of observations[59] at power stations with similar heat discharge systems in a similar climatic region. About the only observable effect expected is the generation of steam fog and/or freezing steam fog over the heated effluent in the discharge canal and over the river prior to complete mixing.

Steam fog is created whenever the air is sufficiently colder and less humid than the underlying water. Church[24] has indicated that steam fog will form if the vapor pressure difference between the air and water is 5 millibars or more and the air temperature is at or below freezing. The air layer next to the water surface is heated and has moisture added; mixing of this air with the unmodified air just above can lead to supersaturation and condensation. Further vertical mixing tends to evaporate the steam fog.

Natural steam fog is fairly common on the Mississippi River, due to the frequent passage of cold air masses from the north over the open river. Due to higher water temperatures, steam fog will be formed over the heated effluent water at times when the surrounding river condition would not form natural steam fog.

Observation of steam fog over thermal discharges indicate that the visible plume will be thin and wispy and that the fog will rarely penetrate more than 10 to 50 feet inland before disappearing. The density of steam fog will not be sufficient to cause navigational problems on the river. The fog is not expected to move inland far enough to cause problems on any public road. Some of the water droplets will be removed by vegetation and other surfaces as they move across the bank, causing a local increase in humidity and dew.

During periods of subfreezing temperatures, the droplets that are swept out will freeze and create a layer of low-density, rime ice on nearby vegetation and structures. Observations at existing stations indicate that this ice rarely, if ever, creates problems to plants or to power lines or similar items.

b. Diffuser-pipe

The system will act to reduce the temperature difference between air and water, and thus reduce the frequency and density of induced steam fogs. Less steam fog problems are expected from this mode of operation.[2]

c. Spray Canal

The spray-canal contains the recirculating heated water. This water has no dilution cooling as it would have if it were discharged into the river. Furthermore, the air-water interface is increased greatly by the many water sprays in the canal. The spray-canal thus has a greater rate of heat transfer to air by conduction and evaporation than a once-through system such as the diffuser-pipe. The visible plume created by the spray-canal will contain drift water droplets in addition to drops from condensed vapor. These drift particles will tend to be larger than those produced by condensation and will add considerably to the wetting and icing potential of the visible atmospheric plume.

In contrast with cooling towers and ponds, there has been little operating experience with large spray cooling systems, especially in winter, the season of most interest. A small spray system has been operated for one winter in New Hampshire. Although not completely analagous, the experience from this system does give some indication of trends that might be expected at the station. This system was designed as a test model and handled 2.5 percent of the station heat output. No serious meteorological problems were experienced last winter.[25] This test system is located in a valley which holds wind velocity low over spray modules low; most of the drift droplets fall back into the canal and are not carried inland. Typically, the steam cloud created by the spray units rose to a height of 200 feet before evaporating and/or moving inland. Hence, icing has not been a serious problem near the canal. On two occasions, the fog has been observed as far as two miles from the canal. Canal-produced fogs, in contrast to natural fogs in this area, are thin and do not reduce visibilities over nearby highways to less than 100 feet. Since no significant environmental problems were observed during the past winter, the New Hampshire utility is now expanding the spray-canal to dissipate the entire heat load from the fossil power plant.

The Commonwealth Edison Company started operation of a spray-canal system at the Dresden Station in August 1971. The Dresden canal has about one-third the heat dissipation capacity of that being planned for Quad-Cities. The basic difference between the Dresden and Quad-Cities canals is Quad-Cities plans to have four rows of sprays along the canal whereas Dresden has two. The Commonwealth Edison Company is sponsoring a full scale study of the fogging and icing potential of the Dresden cooling system which contains a 1200 acre lake in addition to the spray-canal. Although this observation program is quite new, experience[58] at Dresden can be used to predict some atmospheric effects at Quad-Cities. Experience during the summer months gave no indication of environmental problems due to fog from the spray-canal. Some of the winter effects observed are indicated below.

The most severe icing conditions were observed on January 5, 1972. At 0800 E.S.T., when the first visual observation was made, the air temperature was -2.5°F and relative humidity 100 percent. Heavy steam fog was present over the cooling lake (no spray units there); light rime ice 1/4 inch thick was observed on fences and vegetation up to 100 feet from the lake. The horizontal visibility of a highway bridge over the lake was more than 100 feet, and no ice was observed on the roadbed of the bridge.

Over the spray-canal, a dense, thick visible plume rose to a height of 100 to 150 feet; this visible plume extended inland about 300 feet before evaporating.

About 1-1/2 to 2-1/2 inches of hard, dense rime ice was deposited on vegetation and fences next to the canal; this dense ice, with decreasing thickness, was found to extend inland 100 to 150 feet. Light rime ice formed further downwind; up to 1/2 inch thick 500 to 700 feet away, and 1/4 inch at 1000 feet. It was observed that ice formed only on vertical surfaces, such as fences, posts and vegetation. No ice was observed on a road 600 feet downwind of the spray units.

Quantitative estimates of fog and icing potential for the general area from the spray-canal are not possible, in part because the properties of the air downwind of spray units (temperature, liquid water content, drop size distribution, drift content, etc.) as functions of ambient weather (wind speed, air temperature and humidity, stability, etc.) and plant (water temperature) parameters are not known. For most wind conditions, the air will be in contact with the water from the spray for a shorter period than it would in a cooling tower. Thus, the heat and moisture transfer to the air will be slower and more air will be used to cool a given plant load.

Natural fogs in this area tend to occur with weak southerly winds. Since the spray units will act to prolong and intensify natural fog, the winds will cause this fog to move away from nearby roads.

The lowest winter temperatures, and thus the highest probability of steam fog and icing, are associated with winds from the west through north. Thus, the area with the highest incidence of canal-produced fog will be to the SE of the plant, along the railroad and Illinois Route 84. Sections of these traffic arteries are only 600 feet from the canal in this direction.

Based on experience at Dresden and New Hampshire, we conclude that some light fog (visibilities better than 100 feet) can be expected over the roadway near dawn on cold winter (temperature less than 10°F) mornings. Observations of similar areas indicate that within 600 feet of the spray-canal deposits of 1/4 to 1/2 inch of light rime ice can be expected on fences, poles and vegetation along the highway on these mornings, but that no ice layer will form on the roadbed itself.

The fog and icing data collected at Dresden are now being analyzed by Commonwealth Edison. These studies should aid in the ability to predict formation of steam fog and draft and their downwind extent based on weather (air temperature, humidity, wind speed) and water temperature.

Operation of the spray-canal will induce fogs that are less frequent and less dense than the natural fogs which occur in the area. Thus, if any industry in the area emits gaseous effluents, such as SO^2, which can react with fogs and be precipitated locally, the problem will already exist in larger measure from natural fog than from any added increment from the spray canal.

3. Transmission Lines

The transmission of power from the station involves approximately 125 miles of transmission lines. According to the applicants, approximately 45 miles were planned and would have been built even though the station had not been built.

The applicants used the criteria developed by the Department of the Interior[26] in evaluating the design and route of the Commonwealth Edison Company lines. The topography in both Iowa and Illinois is mostly flat farmland with very little crossing of woodland. According to the applicants' report[3] the woodland crossing amounted to approximately 3 miles.

The applicants report the average right-of-way is 145 feet wide. Thus, the 80 miles of transmission lines required by the station represent about 1400 acres. Most of the right-of-way can be farmed or grazed up to the bases of the towers. So the loss of agricultural productivity is small. The transmission lines do interfer with the use of aircraft for spraying. However, aircraft spraying is a practice not regularly used in this region. When spraying is required, aircraft can be used near power lines when the lines are sufficiently high so that aircraft can fly under them. If the lines are too low, normal farm equipment is needed in the immediate vicinity of the lines. The impact of the transmission lines to the view is minimized by the use of a uncluttered type of steel tower with a minimum of lines. (See Figure 14). The effect on the terrain is judged by the staff to be minimal.

In relation to power line interference with rail signals or communications lines, the applicants provided[71] the following statement:

> "All the transmission circuits which have been built in conjunction with Quad-Cities have been constructed so as to minimize any adverse effect on existing railroad signal and communication lines. If any inductive problems arise they are mitigated in an engineering manner which is mutually acceptable to both parties. In the case of the Quad-Cities lines, no inductive problems arose because the lines do not parallel any railroads. Line crossing diagrams were submitted for all railroad crossings in accordance with established procedures."

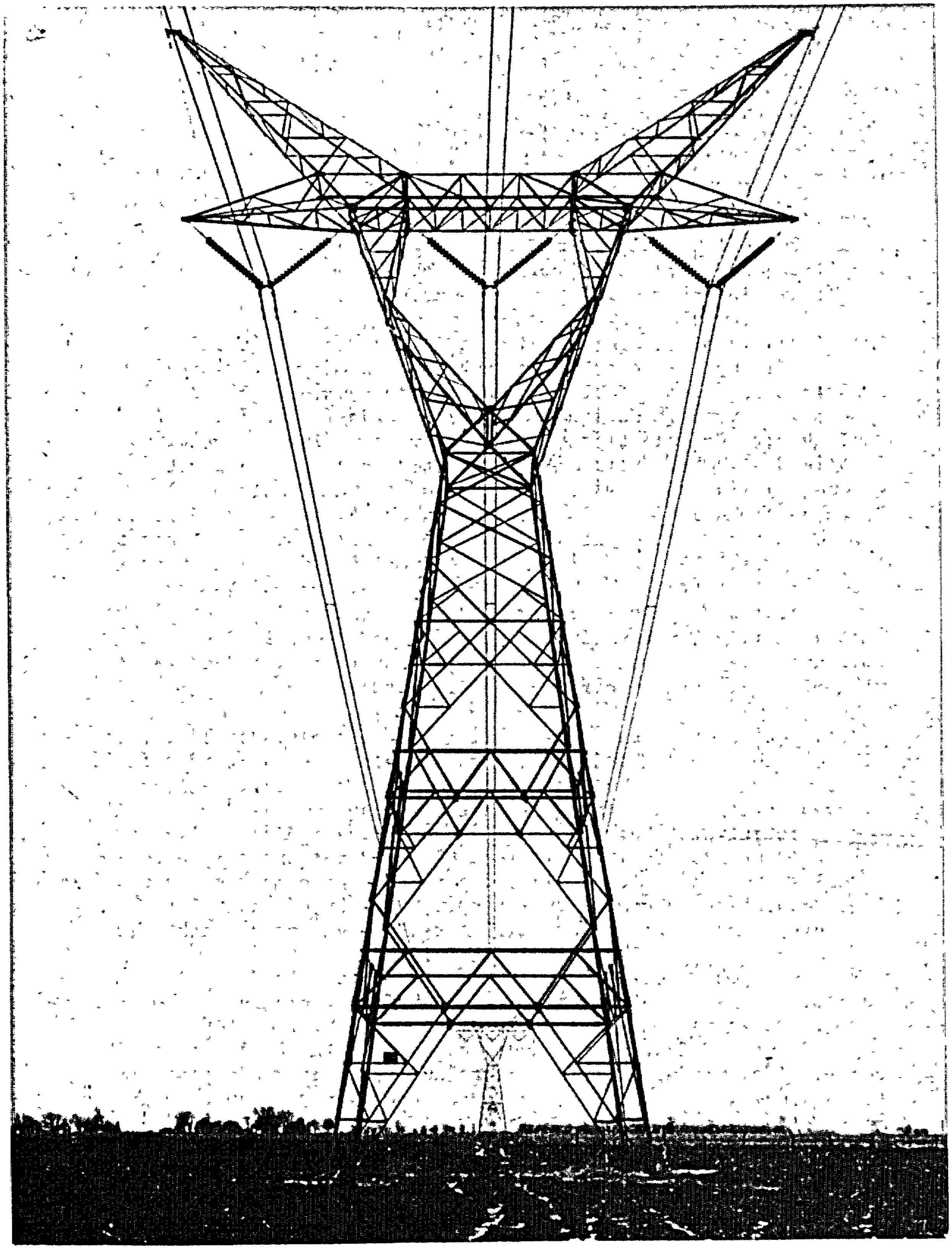

FIGURE 14(3) CLOSEUP VIEW OF TOWER

B. WATER USE

1. River Water

After the start of operations, the applicants state that the station will not receive freight from the river; so no permanent docking facilities will protrude into the river and no obstruction to boating or fishing activities will be present.

The discharge of chemical effluents into the river (see Section III D 3) is not expected to prevent any use of the river water for municipal purposes. Table 9 compares the chemical releases in the discharge to Public Health Service Standards for sulfate and to World Health Organization Standards for magnesium and calcium. (Public Health Service Standards are silent on the latter two elements.) The table also gives the median and maximum values of certain chemicals found in drinking water of the one hundred largest cities in the United States and present content of those chemicals in the river. On the basis of the comparison of the station chemical discharge with the current chemical composition of the river water and the chemical composition of drinking water in use in other cities, we conclude that the station chemical discharge will not have an adverse impact on the environment. The discharge will also meet all required State standards.[34]

Addition of heat to the river will increase the evaporation rate. Although the amount is difficult to assess, a rough staff estimate indicates that about half the heat added to the river will be lost by evaporation. On this basis, the evaporation loss due to full power operation of both units with the diffuser-pipe cooling system will be about 25 cfs which is less than 0.2 percent of the 7-day low-flow average or less than 0.1 percent of the average annual flow. The evaporation rate will increase by a factor of about 1.5 when the spray-canal replaces the diffuser-pipe for one or both units.

For once-through cooling with the diffuser, the increase in temperature of the river varies (see Section V C for details of the temperature increase as well as the biological impact) from 5°F at the edge of the 600 foot mixing zone to 1 or 2°F in the lower part of Pool 14 (except for extreme circumstances). This magnitude of temperature increase is not known to cause any adverse effects on recreational or commercial boating, since the natural temperature variations from day to day or from pool to pool are greater than this amount. (See, for example, the discussion in Section II E.)

TABLE 9

CHEMICAL CONTENT OF WATER (PARTS PER MILLION)

	Quad-Cities Condenser Discharge(a)	Pool[36,37] 14	Recommended Limits of Concentration in Drinking Water	Drinking Water in 100 Largest Cities[51] Median	Maximum
SO_4	≤ 2	28	250[50]	26	572
Mg	≤ 2	16	50[51]	6	120
Ca	≤ 2	39	75[51]	26	145

(a) These concentrations of the listed chemicals are discharged for short fractions of the day and are diluted by the River. When the spray canal is placed into operation, the dilution factor will be reduced by about a factor of 2, thereby increasing the concentrations of these chemicals by a factor of 2.

The applicants made a commitment to change the station cooling water discharge from the side-jet to a diffuser-pipe system and eventually to a closed-cycle spray-canal (see Section III D). The diffuser-pipe system is buried in the river bottom in the main channel of the river. The applicants have designed it so as to not be an obstacle to navigation. This design has been reviewed and approved by Corps of Engineers. The diffuser-pipe is buried in the present bottom of the river so that the highest part of the pipe does not reduce present depth of the river. (See Section IV E). The staff has also reviewed the possibility of jet turbulence influencing the river surface. Considering the depth, the size, the temperature, and the velocity of the jets at Quad-Cities and comparison with the moderate "boil" produced in a more extreme situation at San Onofre,[66] it is estimated that the surface ripples of the boil would be of such an order of magnitude, about 1 inch or less, that no appreciable inconvenience would be offered to small boats. Under all river flow conditions, the water discharged through the diffuser-pipe jets is expected to be within the thermal standards of the States of Illinois and Iowa for this zone of the Mississippi River.

The impact of the condenser cooling water system on the aquatic life follows in Section V C. As a minimum, the applicants will be required to satisfy the water quality standards of the State of Illinois, as well as the water quality standards for the State of Iowa, which also has jurisdiction over the portion of the Mississippi River that is influenced by the diffuser-pipe system. Uncertainties in the effects on the river will be reduced by surveillance of various government agencies, as well as by the monitoring required under the Technical Specifications and the applicants' own study programs.

The effect of the chlorine residual on the aquatic biota is reviewed in detail in Section V C 2. The effect of chlorine residual on the use of the river as a source of drinking water is not considered a problem since much larger amounts of chlorine are normally added to drinking water in the purification process. However, the much higher sensitivity of aquatic life to free chlorine in water is related to breathing rather than to drinking; since dissolved oxygen is about 5 ppm in river water, the presence of chlorine at comparable levels can be expected to be harmful.

The closed-cycle cooling system will provide a generally lower magnitude of effects on water use *per se*. Possible meteorological effects over the river are about the same as for land operations; no appreciable effect is anticipated.

2. Groundwater

The water gradient in the vicinity of the site is from the ground to the river; therefore, under normal circumstances, no chemicals or radioactive materials are likely to enter the groundwater supply after being discharged into the river.

3. Spray-Canal

Operation of the spray-canal for both units will require an average blowdown of about 50 cfs. The applicants plan to operate in such a manner that the blowdown concentration will increase the total dissolved solids in the river water located in the spray canal by about a factor of 2, or 400 to 540 ppm, and thus meet applicable State standards. Makeup water is expected to amount to a maximum of 120 cfs according to the above operation.

4. Sewage Treatment

The station has an operable sewage treatment plant which provides primary and secondary treatment before it is discharged into the river. The maximum amount of effluent is 15,000 gallons per day. This is chlorinated to less than 1 ppm by State regulation; in addition, the small amount of total effluent (0.023 cfs compound to a blowdown of about 50 cfs) is unlikely to be a source of adverse effects. The plant is licensed by the State of Illinois and is under the supervision of a licensed sewage-treatment operator.

C. BIOLOGICAL IMPACT

1. Terrestrial

The principal impact of the station on terrestrial life has already occurred as a result of construction activities (see Section IV). Virtually no clearing was done since the land had nearly all been under cultivation. The station *per se* is not expected to have any further adverse effect on the terrestrial flora and fauna, except to the extent that traffic on access rods and human activities related to station operation may force some wildlife away from the heavily used areas.

The habitat for land animals in the area surrounding the station is not expected to be affected by operation of the station, nor is the station expected to exert an adverse influence on the birds and land animals in the nearby river islands or in the wildlife refuge across the river. As evaluated in Section V D 4, the radiation dose due to operation of the station is not expected to cause an adverse effect on the wildlife.

The impact of the once-through cooling system was judged by the Iowa Water Pollution Control Commission[27] to have a possible adverse effect on the river. As a result of that hearing the applicants were required to construct a closed cycle cooling system for one unit. The applicants selected the spray-canal as the best alternative. A later agreement[72] resulted in a spray-canal large enough to dissipate the heat from both Unit 1 and Unit 2. An additional impact on the terrestrial flora and fauna will result from the construction of the 14,000 foot spray canal. This impact will dislocate some small animals and plants but this is not expected to be a serious problem and the area outside of the canal proper can reestablish itself.

The increased impact on the terrestrial environment due to operation of the spray-canal is primarily that due to the fogging and icing. This will be visible to people traveling by the station and will likely cause some seasonal inconvenience. Since the station is in an area designated as industrial, the visibility of such plumes is not out of character.

The principal impact of the spray-canal on the terrestrial wildlife will have occurred during construction. As indicated, operation of the spray-canal is not expected to cause more than a minimal impact.

2. Aquatic

Factors that need to be evaluated with respect to impact on the aquatic environment include:

- The extent of congregation of fish in the intake area.

- The extent of impinging fish on the intake screens.

- The extent of fish spawning in the intake canal or short distances upstream.

- The magnitude of the effects of entraining very small fish and plankton in the cooling water and thus subjecting these organisms to the full temperature rise produced by the condensers, the toxic effects of intermittent chlorine dosage in the form of sodium hypochlorite, the mechanical effects of the contact with pumps, piping, condensers, etc.

- The extent of the attraction of fish to the effluent discharge area.

- The extent of causing stress to aquatic life in the mixing zone because of elevated temperatures and toxic chemicals.

- The extent of radionuclide accumulations by aquatic organisms from the release of radioactive materials.

- The extent of stress to fish or other aquatic life in the discharge canal due to warm water and/or chemicals during interim operation prior to the use of the diffuser-pipe discharge system.

Since the applicant will replace the diffuser-pipe by the spray-canal most of the above effects will be temporary and the river is expected to recover from such effects that might occur. Those effects which will also occur during operation of the spray-canal will be greatly reduced. As indicated previously, the aquatic ecology of Pool 14 has not been studied in adequate detail to permit an accurate prediction of the above factors. There is a need for more ecological information in order to accurately evaluate the total impact of the station. For instance, knowledge of the population densities, reproductive potentials, and spawning habits of important sport and commercial fish species is requisite to a quantitative evaluation of the probable effects on sport and commercial fishing. This discussion should emphasize, in general terms, those communities or functional groups which can suffer some loss as a direct result of plant operation. Whenever possible, applicable data from similar habitats have been referenced and applied to the discussion to allow the staff to formulate predictive conclusions regarding the potential impact of the station. Further, the AEC will require that the applicants monitor the environment so as to learn as much about the above factors as reasonably possible during operation of the diffuser-pipe system.

a. Heat Removal System Effects

In a temperate habitat such as the upper Mississippi River, fish are adapted to wide seasonal and even short-term temperature changes.

The subject of fish kills is one of obvious importance when considering the impact of a thermal discharge. Despite the concern of many people, very few fish kills have been definitely attributed to thermal discharges from steam-electric plants. In 1968, less than 0.1 percent of the recorded fish kills in the United States were attributed to thermal discharges from electric generating plants with once-through cooling.[8] This is likely due to the ability of the fish to detect and avoid excessive temperatures given a cooler area of retreat. It is unlikely that excessive temperatures from the station discharge will result in mortality of adult fish, however, mortalities may occur from particular station operations (e.g., pumping of water, chlorination, rapid shutdown in winter, etc.) that will be considered in the following discussion.

(1) Condenser Cooling Water Intake

The floating barrier at the mouth of the intake canal was installed by the applicants as a retarding influence on fish eggs and larvae as well as floating debris. We have reviewed the applicants' data as well as searched for additional data elsewhere but have found that there is no evidence available that indicates the effectiveness of the barrier in reducing the flow of fish eggs and larvae into the intake canal, thus protecting them from being entrained in the condenser cooling channel. Some rather large tree branches were observed on the trash racks during the site visit which indicates that the barrier is not completely effective in stopping large pieces of debris.

With the station pumping water at full capacity (2270 cfs), we have calculated the linear velocity of the water at the floating barrier to be about 1 foot per second (fps). Since this velocity is on the same order as current speeds in the river, all but immature fish and plankton will be able to enter and leave the intake canal at will. Some fish and other organisms may purposely enter the intake canal and establish semi-permanent populations. The canal may be an attractive habitat for a variety of reasons, i.e., available food source, spawning site and protective cover. However, should concentrations develop to the extent that high densities result and persist over time, damage to fish is likely to occur due to crowding, increased incidence of disease and entrainment of immature forms.

Trash rack bars, spaced 2-1/2 inches apart and extending to the bottom of the intake canal, are the first obstacle between the floating barrier at the entrance of the intake canal and the condensers. Such a mesh size will certainly permit the passage of small organisms. Small fish can pass between the bars and reach the traveling screens.

A set of traveling screens with 3/8 inch mesh protect the entrance to the pumps and condensers. These screens are normally stationary and change position at preset time intervals or when activated by buildup of pressure due to the collection of debris. Plankton will pass through these screens, as will fish eggs and larvae. The traveling screens are not expected to mechanically damage the larger fish that swim through the trash racks because the screens are not in continuous motion and the water velocity is comparable at this point (a staff calculation indicates about 1-1/2 fps) to river current.[60]

There will be passage of phytoplankton, zooplankton and immature stages of fish through the traveling screens. However, since plankton concentrations in the vicinity of the stations are not well identified, it is not possible to estimate the species and quantities of aquatic life involved. Obviously, if the majority of the spawning adults of a particular fish species spawn immediately above or within the intake canal, the reproductive success of that species will be reduced.

When the spray canal is placed into operation, part of the intake canal will be separated by a divider.[27] This divider is not expected to cause an increase in any of the possible adverse effects in the intake canal. It will have the advantage of reducing the quantity of intake water by approximately one-twentieth and therefore reducing the quantity of aquatic organisms entrained proportionately.

In summary, the non-motile organisms (those which either do not swim or cannot overcome the current) which are small enough to pass through the traveling screens will be entrained in the condensers. Those non-motile organisms which are too large for the screens will be trapped on the screens and lost. Motile organisms, mostly fish, may be attracted to the area between the trash rack and screens and congregate in large numbers. Such congregations could be detrimental to the fish. These problems will occur to some unknown extent, and determination of the degree of occurrence and the need for remedial action, if called for, will be required by the AEC as part of the applicants' environmental surveillance program.

(2) Condenser Passage

In passing through the condensers and the discharge system the entrained organisms will be subjected to a sudden increase in temperature (up to 23°F) and will stay at this higher temperature for about

7 minutes. The entrained organisms will also be subject to periodic chemical damage when sodium hypochlorite is used to clean the condenser tubes, and to continuous mechanical damage due to turbulence and abrasion against tubing walls. These chemical and thermal effects are not readily separable from each other or from the mechanical effects; hence, individual assessment of each effect is difficult. When intake temperatures are relatively high (June, July and August, Table 6), and the reactor is at full power, nearly 100 percent mortality of entrained organisms may occur. However, we do not expect the maximum possible mortality rate of 100 percent of the entrained organisms in the condensers to cause more than a 20 percent (less than one percent when spray-canal is in operation) reduction of the total plankton (assuming plankton population proportional to water intake) immediately downstream during low flow (11,000 cfs). Normally, the river flow is much larger and the percentage reduction of plankton will be much less.

A review of laboratory and field studies of condenser passage effects on such entrained organisms[9] establishes the potential for high mortalities. Studies of the passage of young fish through the condensers of the Connecticut Yankee Atomic Power Plant[10] (using 6 percent of the river during extreme low-flow conditions) causes 100 percent mortality during much of the low-flow period. Nevertheless, no quantifiable adverse effects on fish populations and other biota in the Connecticut River have resulted from more than 30 months of operation.[10] TVA's experience at the Paradise Plant on the Green River in Kentucky shows that zooplankton populations recovered a few miles downstream from a greater than 20 percent reduction in passing through the plant.[12] Studies conducted by Bio-Test Labs at the Riverside Generating Station[68] (Pool 15) showed that during May, June and July 1971, a Δt of 15°F resulted in less than 10 percent mortality of entrained zooplankton.

Based on the above considerations, the staff concludes that even if it is assumed that 100 percent of the organisms entrained in the condenser cooling water system are lost (this amounts to 20 percent of the organisms in the river, at maximum, which is during the lowest flow period, and with both units using the diffuser-pipe or the side-jet), reduction in the number of species or individuals immediately downstream may occur, but the overall community structure of Pool 14 will not be adversely affected.

(3) Condenser Cooling Water Discharge

(a) Side-Jet*

1) Canal and immediate area

a) Considerations of fish

Although the mouth of the discharge canal was necked down to create a current of 4.5 feet per second, many species of fish might have been able to overcome the current and enter the canal. The velocity within the canal proper (2.5 fps) was also well within the sustained swimming ability of many species.[28] Their presence in the canal would have made them subject to potential thermal and chemical effects.

At all power levels fish could have been attracted to the canal and immediate plume area when temperatures there were preferable to ambient conditions. Each species has a preferred optimum, and upper and lower lethal temperature limits based primarily on past acclimation experience. Table 10 summarizes the laboratory and field work of several investigators relative to the temperature tolerances of several species, some of which are common to Pool 14.

Field studies[44,45,28] have shown that a variety of fish species in various numbers is attracted to warm water discharges during different seasons of the year. A recent survey[46] at the Dairyland Power Plant on the Upper Mississippi River (Pool 9) showed that most of the species common to Pool 14 were found in the immediate area of the station's thermal discharge during the summer when temperatures ranged from 2 to 12°F above river ambient. A decrease in fish diversity and abundance observed during winter in the same area was attributed to inefficiency of the sampling method (electric shocker) in obtaining fish that had probably moved to deeper water. Based on

*Since August 2, 1972, this method of cooling has ceased and therefore this discussion is only for the record.

TABLE 10[29]

TEMPERATURE TOLERANCE LIMITS FOR SELECTED FRESHWATER FISH, LD_{50}[a]

Fish	Acclimat. Temp. (°F)	Low. Temp. Lim.		Up. Temp. Lim. (°F)		Preferred Temp. (°F)	
		°F	Time, Hr.	°F	Time, Hr.	Lab.	Field
Bass, largemouth	68.0	41.0	24	89.6	72	86.0-89.6	80.0-81.9
	86.0	51.8	24	93.2	72		
Bluegill	59.0	32.0	24	86.0	60	90.1	
	86.0	51.8	24	93.2	60		
Catfish, channel	59.0	32.0	24	86.0	24	-	-
	77.0	42.8	24	93.2	24		
Yellow perch	41.0	-	-	69.8	96		
(winter)	77.0	39.2	24	86.0	96	75.6,	54.0,
(summer)	77.0	48.2	24	89.6	96	69.8	68.4-69.8
Carp	-	-	-	-	-	89.6	-
Walleye	-	-	-	-	-	-	69.1, 72.9-73.8

(a) Values are water temperatures in which 50 percent of the test fish survived. See reference 29 for specific experimental conditions and degree of applicability to present use.

observations at the Dairyland Power Plant, endemic (native) fish species in the station's environs would have been expected to be found in the discharge canal and immediate plume area at 20 percent (ΔT 4.6°F) and 50 percent (ΔT 11.5°F) discharge of station power during summer. At full station power (ΔT 23°F) canal and near-site surface water temperature probably approached 100°F. Although 100°F exceeds the laboratory determined thermal tolerances of several local species (Table 10), the ability of these species to acclimate to this high temperature in their environment is unknown. It is conceivable that one or more of the more temperature tolerant native species (e.g., largemouth bass, bluegill, carp, etc.) could acclimate and reside in 100°F discharge water. If the discharge temperature was above their preferred optimum, the fish would have no doubt evacuated the area.

During periods of low river temperatures, fish that were attracted to the discharge canal and the plume area probably became acclimated to warmer than ambient river temperatures with a subsequent rise in their lower lethal temperatures. In the case of rapid station shutdown, these fish would have been exposed to a rapid return to ambient temperatures and would have experienced cold shock, which may be a potentially greater threat to fish than increased temperature. Mortality resulting from the inability of fish to acclimate to rapidly lowering temperatures in natural systems has been reported.[29] On the other hand, a study[64] shows that many warm water species of fish (e.g., largemouth bass and sunfishes) can tolerate rapid temperature increases and decreases of up to 20°F; mortalities which resulted from temperature changes of this magnitude varied with species and generally were restricted to diseased or otherwise stressed individuals.

In summary, the degree of fish congregation in the discharge canal and in the immediate plume area was not predictable.

b) <u>Considerations of Invertebrates</u>

The heated discharge from the canal could have affected certain benthic species such as mayfly nymphs, caddisfly larvae, crayfish, freshwater clams and other mollusks, and also affected plankton, fish eggs and larval forms within the established mixing zone (600 feet) of the discharge. There are only a few aquatic plants in the discharge area that might have been affected. Reference to Figures 11a to d and section III D 1 indicates that for the lowest daily flow since 1938 (11,000 cfs) and 100 percent station power, temperatures would be greater than 9°F above ambient and probably on the order of 10 to 20°F above ambient at 6 feet below the surface in the mixing zone. It is believed that temperatures in this range are representative of the maximum bottom temperatures that would have been encountered in this zone.

There are no temperature tolerance data available for the benthos of plankton native to the station environs that would have encountered the maximum temperature increases. A recent report[47] suggests that many members of the freshwater benthos are eury-thermal (temperature tolerant). They are capable of residing in water in which the temperature may vary over a considerable range. Plankton and larval forms that would have drifted into the plume would have not only undergone a rapid rate of temperature change but would have remained in a warm plume for some minutes. The temperature-time relationships with respect to mortality are unknown for these planktonic species. Studies[48] to simulate effects on algae from passage through condensers indicate that little harm occurs if temperatures are below 95°F. A laboratory study[12] at a TVA plant on the Green River showed that there was little mortality of the dominant zooplankton species until 97°F was reached.

Studies of several populations (at the community level) have reported[9,12,29,30] the thermal effects observed in discharge canals and their near environs for a number of plants. The most prominent effects attributed to station operation were seasonal changes in animal diversity and total number of organisms present. Unfortunately, little information is available on seasonal diversity and abundance changes before plant startup in these studies. At several stations during the summer months, animal diversity and numbers were reduced, indicating thermal stress in the immediate discharge area. During winter at these stations, diversity and numbers of organisms increased. Phytoplankton primary production has also been shown to be affected by an increase in water temperature.[31] Depending on the ambient water temperature and other factors, production can be either increased or decreased.

The studies cited above at particular plants show localized damage but no widespread changes of the nature described have been observed that clearly indicate point sources of heat as the cause. Benthos and plankton could have been exposed to temperatures approaching 95°F in the vicinity of the discharge at full station power. Those less temperature tolerant mobile benthic forms probably evacuated the area while those that are sessile (non-mobile) perhaps did not survive. In general, the conditions previously described as having been observed at other installations (e.g., seasonal changes in species diversity and abundance that can be attributed to plant operation) probably occurred. At 20 and 50 percent of station power these effects were correspondingly less. At half station power (ΔT 11.5°F) seasonal changes in diversity and abundance may have been detectable in the immediate discharge zone. However, such changes probably were not measurable at 20 percent of station power (ΔT 4.6°F).

2) Downstream Areas

Downstream areas that experienced temperature rises consist primarily of the channel, channel border, littoral regions along the river banks and a small area of islands. The small island area is about 5 or 10 percent of the total downstream island and slough habitat area. The total downstream island and slough habitat area is about 5 percent of the total downstream area of Pool 14. As indicated earlier, the extent of slough and island area habitats upstream of the plant is about five times that of similar habitat areas downstream of the plant. Although the island area has been shown to be frequented by many of the sport and commercial species of interest in Pool 14,[65] it appears that upstream island areas are utilized to a greater extent by these species. It is certain that the small downstream island area is utilized for spawning during the spring by some of these species (such as sunfishes, bass, and catfish). However, it is doubtful that significant spawning occurs during other seasons (June-February).[65]

The previously described model studies predict plume from the side-jet could have been discernible for a number of miles downstream. For river flows in the range of 11,000-13,500 cfs, the discharge could have extended across the river to the Iowa shore. Some plume water could also have entered Steamboat Slough from the north. Under these conditions water temperature rise on the order of 3 to 7°F above ambient could have been expected in these areas at full station power and low river flow. However, the low flows and hence this temperature distribution would have been of short duration (i.e., on the order of a day) and probably seldom occurred (Table 5 and Figure 12). The predominant situation was expected to be that of river flows greater than 13,500 cfs (average flow 46,800 cfs) in which the thermal plume would have been carried downstream in the main channel flow.

As previously mentioned (III D C), for river flow of 30,000 cfs the upstream portion of the island area might have experienced surface water temperature 16°F above ambient and the downstream end might have been as high as 10°F above ambient at full station power. For 50 percent of station power the temperatures probably were those predicted by the hydraulic model studies (Figures 11a to 11d).

Ambient temperature in the various habitats below the plant fluctuate markedly on a seasonal and daily basis. During winter, diurnal variations of water temperature in the main channel range from about 0.3 to 1°F; larger variations occur during other seasons (e.g., 2 to 3°F main channel, 6°F in sloughs). Quiescent sloughs during the summer can have maximum temperatures 18°F greater than maximum temperatures observed in the main channel. For low current slough areas the temperatures are often higher than the main channel by 6 to 10°F.[55,60]

At full station power temperature ranging from 10 to 16°F (surface) and 4 to 12°F (near-bottom) were superimposed on the natural temperature cycle in the island area downstream. It is highly likely that the effects mentioned previously in the discussion of the immediate discharge area occurred here. Less temperature tolerant fish and motile invertebrates probably retreated from the region and probably sought comparable habitats lower in the pool or above the station resulting in a change in species diversity and abundance of organisms in the island area. Observations from the Dairyland Power Plant study[46] would suggest that some of the native fish species would have remained in the area. Species diversity and abundance in the region would probably have varied on a seasonal basis in a manner different than that prior to plant startup with lowest and highest values in the summer and winter, respectively.

More temperature tolerant and less desirable forms of plant and animal life (e.g., blue green algae and oligochaete worms) might have become more abundant. Limited work[11] on the temperature tolerance of aquatic plants suggests that endemic species may be replaced by more temperature tolerant plants.

Several of the more subtle effects that stations operation could have had on the biota of this area (e.g., feeding, growth, and reproduction) could not be fully evaluated. For example, a recent investigation[7] has suggested that damage could occur to walleye and sauger reproductive success as a result of increased water temperatures.

This study was performed with yellow perch and determined that pre-spawning (over winter) temperature of >39°F reduced spawning success (percent fertile eggs and percent normal larvae). Extrapolation of this laboratory work on yellow perch to walleye and sauger is, at best, questionable. Not only are the temperature requirements different for these species, but each has its characteristic spawning behavior and site preferences. Limited information[56] on the time, temperature and site of spawning for walleye and sauger in Pool 14 indicates that dam tailwaters are preferred for spawning when water temperatures range from 45-49°F (March-April). Obviously, during some portion of the pre-spawning period, natural water temperatures exceed 39°F.

Indeed, these naturally occurring, higher than optimum temperatures in Pool 14 may be one factor contributing to the reduced abundance of these species (Pool 14) relative to upstream pools. A shortening of fish spawning and insect[32,33] hatching time could result from warm exposure. An updating of fish spawning time without the availability of prey organisms for the developing larvae could result in some loss of the population recruitment. However, the staff is not aware of any documented loss resulting from the lack of food for a prematurely spawned fish population. The addition of warm water to the island area might have resulted in some loss of spawning area to those species believed to be major users of the area (e.g., bass, bluegill, catfish, etc.). Even loss of the total area (5 to 10 percent of this habitat type occurring downstream) should not adversely affect the total fish population of Pool 14, because it is only a small percentage of the downstream area of this type and an even smaller percentage of the upstream area of this type.

At all power levels changes in diversity and abundance of organisms might have occurred in the island area. In cases where organisms are presently existing at their optimum temperature, any heat addition could have eliminated them from the area by causing them to move away or to die. It is highly unlikely that the loss of particular organisms or the majority of biota in the island area would have adversely affected the overall ecological balance of Pool 14. Continuous downstream drift of river flora and fauna is well known[62] and with cessation of the side-jet discharge those organisms having previously been eliminated from the area can be expected to return.

Downstream of the island area, the thermal plume was primarily a surface phenomenon (less than 6 ft depth). At 50 percent station power and river flow equal to 30,000 cfs (a condition illustrated by the applicants' monitoring studies), it is estimated that the three degree Fahrenheit isotherm extended less than 10 miles downstream; at 100 percent power, less than 17 miles downstream.

Benthic species in the channel and littoral habitats may have experienced little if any exposure from the plume. Planktonic species, especially in the channel area, probably experienced a relatively small and insignificant temperature increase. Most fish species in the downstream area were expected to be unaffected since the same species are known to occur in Pool 26, approximately 300 miles downstream where monthly average temperatures are 1 to 5°F higher than in Pool 14.

In summary, the biotic community of the downstream island area may have been altered as a result of station operation. Changes in the number and kinds of species and the productivity of the area may have occurred. The magnitude of these changes was probably a function of the station's power level. Since operation utilizing the side-jet did not extend beyond August 2, 1972, any effects described are not expected to be permanent. Flora and fauna downstream of the island area are not expected to have experienced adverse effects from station operation. The applicants will submit a report, as indicated in the Technical Specifications, which will determine the nature and extent of changes (if measureable) induced by the thermal plume, especially in the island area below the station.

(b) Diffuser-Pipe

The discharge of condenser cooling water from the diffuser-pipe will result in essentially complete mixing within 200 feet downstream. The resulting temperature increase after complete mixing will never exceed 5°F and will be only 1 to 2°F above ambient most of the time. This is based on the modeling studies.[34] The tests are summarized in Table 5 and results of tests 10 and 11 are given in figures 13a to 13d.

Within the short mixing zone, from the diffuser-pipe jet ports at the river bottom to 600 feet downstream, plankton, fish eggs and larvae drifting downstream will be subjected to rather sudden increases in temperature ranging from nearly the same as in the condensers to 1 to 5°F above ambient depending on plant load and river flow. The organisms entrained with the heated effluent near the diffuser-pipe ports will be subjected to turbulence and an increase in temperature almost as high as that experienced by organisms passing through the condensers and the time of exposure to temperatures above that of the full mixed discharge will be relatively short. (A staff calculation indicates this exposure is about 1 minute, compared to about 7 minutes for passing through the condenser and diffuser-pipe).

When relatively low river flows coincide with high ambient water temperatures, a reduction of at least 20 percent of the living plankton may be found immediately in and below the short mixing zone (600 feet below the diffuser-pipe) resulting from the heavy mortality of organisms passed through the condensers and losses of plankton entrained by discharge water. In addition, temperature increases in the immediate discharge area may alter the photosynthetic capability of plankton.[31,42] A zone of inhibition of plankton productivity may occur in this area. This may be followed by a zone of recovery due to acclimation of most species and stimulation of others. The zone of recovery could very likely be followed by an extensive zone of increased plankton productivity due to a shift in species composition towards a greater prevalence of temperature tolerant forms, such as blue-greenaalgae. The frequency of short-term blue-green algae blooms, downstream in Pool 14, may increase, but blue-greens are not expected to become generally predominant in the plankton. According to McDonald[19] "the fully mixed temperatures below the plant will be, even at these low flow conditions, about the same as the temperatures prevailing in Pool 19." A recent study of phytoplankton and their ingestion by fingernail clams in Pool 19[17] indicates that diatoms are generally dominant, although green algae and; to a lesser extent, blue-greens are more abundant in the summer months than at other times of the year. The abundance of Hexagenia nymphs in Pool 19[18] also suggests that these burrowing mayflies will not be significantly affected in Pool 14 by the operation of the proposed diffuser-pipe, even at low river flows.

During less critical periods, i.e., when river flows are not unusually low and ambient temperatures are not high, zones of inhibition, recovery, and stimulation may still be observed below the mixing zone, but their relative magnitude will probably be smaller. In winter the zone of thermal inhibition may disappear.

The rapid exit velocity from the diffuser (10 feet/second) seems to preclude any possibility of fish entering the discharge ports. However, warm, flowing water is attractive to many fish and it seems likely that some species will congregate near the diffuser. Fish attracted to the diffuser discharge area will potentially be subjected to cold shocks should the station undergo a rapid shutdown.

In addition, fish attracted to the diffuser-pipe may be exposed to water supersaturated with gases, resulting in the development of gas-bubble disease. Studies during 1969-71 at the Duke Power Company Marshall Steam Plant on Lake Norman, North Carolina, by the North Carolina Division of Inland Fisheries have found substantial incidence of gas-bubble disease among fish residing near the discharge canal.[20] Incidence of gas-bubble disease was determined to be as high as 70 percent in white bass, 33 percent in shad, and 23 percent in bluegill. In all, symptoms were detected in fish collected from two similar control areas. In 1971, a die-off of black crappie (∿300 fish) at Lake Norman was attributed to internal emboli (gas-bubbles).

The species of fish which will probably congregate in the warmed discharge from the Quad-Cities Station are the same as or similar to those affected at the Marshall Steam Plant.

The staff concludes that the diffuser-pipe condenser cooling water discharge has a smaller environmental impact on the aquatic biota because it disperses the heat more rapidly throughout the river and has a smaller high-temperature-zone than the side-jet. Since the high temperature zone is likely to be the zone of maximum biological effect, the diffuser minimizes the above effects more than any other once-through cooling system. However, the diffuser-pipe, or any once-through cooling system after complete mixing, raises the temperature of the river. This temperature increase may tend to change the temperature character of the lower half of Pool 14 to that of downstream pools.

In summary, our analysis indicates that operation with the diffuser-pipe for the interim period will not have a significant adverse impact on the quality of the environment. In order to assure this, a monitoring program with semiannual reporting will be required of the applicants as delineated in the Technical Specifications. The reports will indicate what steps the applicants have taken to assist natural recovery of any short term recoverable environmental affects. The applicants will also be required to determine the dimensions of the thermal plumes resulting from operation of the diffuser. In addition, the effects of discharged diffuser water on plankton and fish will be evaluated by the applicants.

(c) Spray-Canal

The major impact on the area around the station due to operation of the spray-canal is terrestrial rather than aquatic. (See section

V A 2.) There will be some consumption of water due to evaporation (see sections V B 1 and V B 3), some concentration of river chemicals due to this evaporation, and some warm water discharge to the river. (See section III D 1 C 3.) The discharge of heated water is reduced from 2270 cfs under full open cycle cooling to an average of about 50 cfs for complete closed cycle cooling. Makeup water requirements for continuous operation of both units on the spray canal are 68-125 cfs. The maximum percentage of river flow used for makeup is about 1% (based on low flow value of 11,000 cfs). Even if all entrained organisms are destroyed in the spray canal, the small losses will not affect the ecological stability of Pool 14. After evaluating the above mentioned effects, we conclude that there is not likely to be an adverse impact on the aquatic life or the use of the river due to the operation of the spray-canal.

b. Chlorine Residual Effects

Sodium hypochlorite solution is added intermittently (40 minute periods, 3 times per day) to the condenser cooling water to reduce the growth of bacteria and other microorganisms in the piping and condensers. Present practice is to maintain a 0.2 to 0.7 ppm free chlorine residual in the center water box of each condenser half. The concentration of chlorine residual in the discharge canal was expected to vary from as much as 0.25 ppm at the condenser exit to something much less at the canal exit. The uncertainty in these numbers stems from the variability of the chlorine demand of the river water and of the mixing in the canal. The levels of free and combined chlorine in the discharge bay, now that the diffuser-pipe is in operation, will be limited to 0.1 ppm.

Chlorine and chloramines are known to be toxic to aquatic life[38-43]. Although the levels at which effects have been observed are subject to many conditions (e.g., the chemical nature of the receiving water, species and life stage of aquatic organisms, temperature, pH, etc.), levels as low as 0.001 ppm have been shown to cause effects. Rainbow trout behavior is affected by continuous exposure to 0.001 ppm free chlorine[13] and Daphnia sp. (zooplankton crustaceans) are killed by 3-5 days exposure to 0.001 ppm chloramines.[65] Total residual chlorine concentrations of 0.4 - 1.0 ppm/1 hr. have been shown to be lethal to many species of fish such as the white sucker, largemouth bass and yellow perch. Salmonids are capable of detecting and avoiding concentrations of 0.01 ppm free chlorine[13] and, presumably, warm water fish have similar avoidance reactions.

Based on the intermittent schedule of chlorination (3 times/day) the brief period of exposure (40 minutes), and the projected low concentrations in the discharge bay (<0.1 ppm), it is not anticipated that damage will result to aquatic biota.

Certainly, during periods of chlorination, condenser entrained organisms will be adversely affected, resulting in death to some plankton and fish larvae, and perhaps a temporary reduction in phytoplankton productivity will occur. However, the schedule of chlorination and projected low discharge concentrations would seem to preclude any adverse effects on downstream ecology.

An additional amount of chlorine will be added to the discharge bay in the service water discharge. As indicated in Section III the service water is chlorinated for two 20-minute periods per day, during which the residual chlorine in the 67 cfs (30,000 gpm) discharge from the service water unit will be about 0.5 ppm. (Like the condenser cooling water, it is expected to vary in the range 0.2 to 0.7 ppm.) Possible contribution to the river during chlorination is about five percent that of the condenser chlorination. This is not expected to add a measurable amount to the chlorine released from the condenser cleaning. In any event, it will be included in the limit of 0.1 ppm permitted in the discharge water.

Due to the fact that the operating specifications for the spray-canal are not yet available, evaluation of potential chlorine discharge effects during spray-canal operation is not possible. However, it is anticipated that chlorine discharges to the river will be significantly reduced below the levels expected during operation of the diffuser-pipe discharge. Technical Specifications covering the release of chlorine during operation of the spray-canal will be at least as restrictive as those covering release of chlorine during operation of the diffuser-pipe discharge system.

D. RADIOLOGICAL IMPACT

The AEC's licensing procedure involves a review to insure that radiation exposure of persons living near the plant will be as low as practicable. This is in accordance with 10 CFR Part 50 and will assure much lower radiation release levels than the limits set by 10 CFR Part 20.

The radwaste systems have been described in Section III D 2 of this statement. Tables 6 and 7 in that section present identities and quantities of radioactive material anticipated to be released from the plant in gaseous and liquid effluents, respectively. The postulated release values are based upon experience[61] with comparable operating reactors and an evaluation by the staff of the procedures, equipment, and mode of operation at this specific station. The calculations for the dose rates have been made for the gaseous and liquid effluents within a 50-mile radius of the station, before the modifications to the liquid and gaseous radwaste systems are completed.

Estimates have been made of the exposure of persons to radiation from the station. The radiation dose estimates are based upon the postulated release of radioactive material, presented in Tables 6 and 7, the population distribution, the various dispersion modes applicable for the area, and the normal activities which determine the degree of intake or exposure by the individuals. (Specific data on meteorology, hydrology, and population distribution are presented in Sections II and III of this statement and the FSAR.) External exposure modes considered were the direct exposure from passing effluent clouds and from submersion in water (swimming). Internal exposure modes considered were those from ingesting food and water affected by the effluents and from breathing air containing effluents. The results of the radiation dose estimates are presented in Table 11 as annual averages to individuals at various locations.

1. Gaseous Effluents

For normal conditions with both units operating at full power, the release rate for noble gases from the station is estimated to be about 130,000 μCi/sec* (see Table 6). However the applicant has committed himself to a maximum annual release rate of 110,000 μCi/sec in the Technical Specifications for the plant and this level can be realized. At this latter release rate, the exposure to persons in the off-site environment would not exceed 70 mrem/yr, if a factor of 2 is allowed shielding and occupancy factors. In Table 12, the cumulative population, cumulative population dose (man-rem), and average individual dose (mrem/yr) from the release of noble gases are presented for various radial distances from the station.

*Based on an independent evaluation of the radwaste systems by the staff with conservative assumptions about fuel failure and leak rates. Thus, it can be considered as an upper limit to the expected release rate. In any case, the applicant will be required to comply with the Technical Specifications.

TABLE 11

ANNUAL AVERAGE DOSES TO INDIVIDUALS AT VARIOUS LOCATIONS

Location	Pathway	Whole Body Dose (mrem/yr)	Thyroid Dose (mrem/yr)
Boundary (N)	Cloud	70 (4.4)*	70 (4.4)*
	Inhalation		0.26 (0.14)
3 Miles SE of Station	Ingestion of Milk**		80 (2.2)
	Inhalation		0.64 (0.02)
Discharge Point	Ingestion of Water	0.24 (0.48)	1.7 (3.4)***
Mississippi River	Ingestion of Water	0.016 (0.0008)	.035 (0.002)
	Ingestion of Fish	0.13 (0.007)	0.81×10^{-3} (0.4×10^{-4})
	Swimming	1.7×10^{-4}	1.7×10^{-4}

*The amounts in parentheses are doses after installation of modified radwaste treatment system.

**Dose to child from a daily intake of 1 liter of milk derived solely from cows grazing at the site of maximum deposition for 6 months per year.

***Dose to child from daily intake of 1 liter of water.

TABLE 12

CUMULATIVE POPULATION, ANNUAL MAN-REM DOSE,[a] AND AVERAGE ANNUAL DOSE IN SELECTED CIRCULAR AREAS AROUND QUAD-CITIES NUCLEAR STATION

Cumulative Radius (miles)	Cumulative Population (1970)	Cumulative Dose (man-rem)	Average Dose (mrem)
1	55	0.93	16
2	195	2.0	10
3	430	2.6	6.2
4	1,575	5.3	3.3
5	5,845	15	2.5
10	26,739	35	1.3
20	303,741	87	0.29
30	415,500	96	0.23
40	509,583	99	0.20
50	601,846	101	0.17

[a]This dose is from noble gas releases before the modification of the gaseous radwaste systems. When the new system is installed, the doses will be reduced by a factor of about 16.

After installation of the modified gaseous waste treatment system (expected completion in 1974) proposed by the applicant, exposure to individuals off-site would not exceed 4.4 mrem per year.

The release rate for iodines with both units operating at full power is anticipated to be about 204 Ci/yr prior to modification of the system* (Table 6). Most of this iodine will be released through the stack, and the maximum off-site concentration will occur at a point 2 miles NE of the station ($\chi/Q = 2.7 \times 10^{-8}$ sec/m^3).** The dose from inhalation to the thyroid of an adult who resides at this location full time would be 0.75 mrem/yr. The nearest dairy is located one mile south of the plant ($\chi/Q = 0.8 \times 10^{-8}$ sec/m^3). The dose to the thyroid of a child who drinks 1 liter of milk per day produced by cows grazing at this location for 6 months per year was estimated to be 39 mrem/yr.

After installation of the modified radwaste system, the iodine releases will be considerably reduced. Maximum off-site concentration will then result at the boundary in the northern direction ($\chi/Q = 1.2 \times 10^{-5}$ sec/m^3) from ground level releases. The inhalation dose to the thyroid of an adult is estimated to be about 0.14 mrem/yr at this location. The thyroid dose from inhalation at all other off-site locations will be lower. The dose to the thyroid of a child who drinks milk produced at the nearest farm will be about 2.0 mrem/yr.

2. Liquid Effluents

The applicants' liquid-radwaste procedures, as noted in Section III D 2, are such that the expected annual average concentration after mixing with the station coolant water at a flow rate of 2270 cfs will be about 1.5×10^{-8} microcuries per milliliter. After installation of the modified radwaste treatment system, the radioactive liquid releases will be reduced by a factor of about 20. The installation of the spray-canal will reduce the station coolant water discharge from 2270 cfs to 50 cfs. The expected annual average concentration in the Mississippi River will be about 10.5×10^{-10} microcuries per milliliter before the radwaste system is modified and 5.2×10^{-11} microcuries per milliliter after the modification. Maximum doses to individuals off-site are expected to be less than 0.15 millirem per year even if an individual were to use the Mississippi River as a sole source of liquid intake

* Based on an independent evaluation of the radwaste systems by the staff with conservative assumptions about fuel failure and leak rates. Thus, it can be considered as an upper limit to the expected release rate. In any case, the applicant will be required to comply with the Technical Specifications.

** The joint frequency data from which the atmospheric diffusion rates were determined is contained in Amendment 18 to the FSAR.

(2200 cc per day) and in addition eat 50 gm of fish per day (40 pounds per year) from the River. The total body dose to an individual who swims for 100 hr per year in the Mississippi River will be about 1.7×10^{-4} mrem/yr.

3. Doses to the Regional Population

In 1963, the total fish catch from the Mississippi River from Iowa, Illinois, and Missouri was 9.3 million pounds, and represents a potential dose of about 30 man-rem when consumed. The dose to the population within a 50-mile radius of the plant from drinking Mississippi River water will be about 10 man-rem, while the dose from gaseous effluents will be about 100 man-rem. If 10% of these people are assumed to swim in the river 100 hr per year below the discharge, the dose will be about 0.01 man-rem. Thus, based on our conservative estimate, the total man-rem dose from all effluent pathways to the 600,000 persons who live within a 50-mile radius of the plant, as shown in Table 13, would be about 143 man-rem per year if the station is operated at full power. By comparison, the natural background dose of about 0.1 rem per year per person results in an annual total of 60,000 man-rem for this same population.

Thus, based on the calculations in the preceding section, operation of the station under full power license will contribute only an extremely small increment to the dose that the area residents receive from natural background. Since fluctuations of the background dose may be expected to exceed this small increment, the dose will be immeasurable in itself and will constitute no meaningful risk.

4. Radiation Dose to Species Other Than Man

Of the lower organisms which inhabit the environment of the station, those which will receive the most significant dose are the aquatic organisms which are likely to live in the discharge canal.* The calculated dose to those organisms is based on the releases listed in Table 7 and the bioaccumulation factors[49] for these isotopes and shown in Table 14. The average annual dose rates to fish, invertebrates, and plants would be 30, 110, and 380 mrad, respectively. The dose rates to aquatic organisms living in the Mississippi River would be lower by a factor of at least 14. Terrestrial organisms in the environs of the station would receive approximately the same radiation doses as those calculated for man. There is no evidence that

*Since the diffuser-pipe has replaced the side-jet this no longer is a possibility; however, the analysis is left here for comparative purposes.

TABLE 13

ESTIMATED ANNUAL MAN-REM DOSES
FROM QUAD-CITIES STATION

Pathway	Population	Man-rem/yr
Ingestion of Water*	600,000	10
Ingestion of Fish*	230,000	30
Cloud*	600,000	101 (6.3)**
Swimming	60,000	0.01
Transportation	200,000	3
		∿143 (49)**

*Within 50-mile radius of Station
**The number in parentheses is the man-rem dose after modification of the radwaste system.

TABLE 14

BIOLOGICAL ACCUMULATION FACTORS
FOR RADIONUCLIDES IN FRESHWATER SPECIES

	Biological Accumulation Factors		
Radionuclide	Fish	Invertebrates	Plants
Cr-151	200	2,000	4,000
Mn-54	25	40,000	10,000
Fe-55	300	3,200	5,000
Co-58	500	1,500	1,000
Co-60	500	1,500	1,000
Sr-89	40	700	500
Sr-90	40	700	500
Zr-95	100	1,000	10,000
I-131	1	25	100
I-133	1	25	100
Cs-134	1,000	1,000	200
Cs-137	1,000	1,000	200
Ba-140	10	200	500
Ce-144	100	1,000	10,000

dose rates of these magnitudes will cause any detectable harm to the above terrestrial or aquatic organisms. No guidelines have been established for radiation exposure of species other than man, but it is generally agreed that the limits established for man are very conservative when applied to plants and lower animals. On the basis of this reasoning, we conclude that there will be no adverse impact on species other than man due to radiation exposure caused by operation of the station.

E. TRANSPORTATION IMPACT

The AEC is preparing a general analysis of the impact on the environment caused by transportation of radioactive wastes. This study includes a detailed analysis of radiation exposures during normal transportation of radioactive materials as well as accidents occurring during the transport of radioactive materials. The study is being developed in cooperation with other appropriate Federal agencies and will be published soon. The following section is based on information generated in the above study which has been adapted to the station.

1. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste (quantities of these materials for this station are given in Section III E) is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments are therefore subject to normal accidents (see Section VI B), just like nonradioactive cargo. Safety in transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated[63] at the Federal level by both the Atomic Energy Commission (AEC) and the Department of Transportation (DOT). In addition, certain aspects, such as limitations on gross weight of trucks, are regulated by the States.

The probability of accidental releases of low level contaminated material has been calculated and found to be sufficiently small that, considering the form of the waste, the likelihood of significant exposure is extremely small. Packaging for these materials is designed to remain leakproof under normal transport conditions of temperature, pressure, vibration, rough handling, exposure to rain, etc.

For large quantities of radioactive materials, the packaging design, Type B packaging,[64] must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe impact. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.[52]

In addition, the packaging must provide adequate radiation shielding to limit the exposure of transport workers and the general public. For irradiated fuel, the package must have heat-dissipation characteristics to protect against overheating from radioactive decay heat. For cold and irradiated fuel, the design must also provide nuclear criticality safety under both normal and accident damage tests. Each package in transport is identified with a distinctive radiation label on two sides, and by warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[53] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. The consequences of an accident may, in many cases be reduced by procedures which carriers are required[54] to follow. These procedures include segregation of damaged and leaking packages and the notification of the shipper and the Department of Transportation that an accident has occurred. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

2. Exposures During Normal (No Accident) Conditions

a. Non-irradiated Fuel

There will be essentially no effect on the environment during transport under normal conditions since the quantities of nuclear radiation and heat emitted by non-irradiated fuel are small. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 10 shipments of 16 packages (2 fuel elements per package), with two drivers for each shipment, this would be a dose of about 0.07 man-rem* per year. The exposure of an individual in the general population near one of the transport trucks would be no more than about 0.005 mrem per shipment. This is based on the radiation level associated with each truck load of cold fuel being less than 0.1 mrem/hr at 6 feet from the truck.

b. Irradiated Fuel

The applicants indicate[3] that shipment from the station will carry an average of 24 irradiated fuel elements each. Based on actual radiation levels associated with shipments of irradiated fuel elements, we estimate the radiation level at 3 feet from the car to be about 25 mrem/hr.

Train brakemen might spend a minute or two each in the vicinity of the cask car (i.e., at an average distance of 3 feet) during the trip, for an exposure of about 0.5 mrem each. With 10 different brakemen involved along the route, the total dose for 7 shipments during the year is estimated to average about 0.04 man-rem.

The staff has estimated that the distance to the reprocessing plant is 700 miles.** Based on this number of miles and the average population density of the eastern part of the country, a staff derived number of people along the route is 200,000 persons. The dose to these people caused by the transport of irradiated fuel from the site to the reprocessing plant is about 0.1 man-rem. This is less than natural background (100 mrem per year or 20 man-rem). The regulatory radiation level limit of 10 mr/hr at a distance of 6 feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and 1/2 mile on both sides per day and the population density would average 330 persons per square mile along the route.

*Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 10^5 persons along the shipping route).

**The applicants have not indicated the fuel reprocessing site so these exposures are based on an estimated average distance from the station to the reprocessing site.

The amount of heat released to the air from each cask will be about 250,000 Btu's per hour. For comparison, 35,000 Btu's per hour is about equal to the heat released from an air conditioner in an average-sized home. Although the temperature of the air which contacts the loaded cask may be increased a few degrees, because the amount of heat is small and is being released over the entire transportation route, no appreciable thermal effects on the environment will result.

c. Solid Radioactive Waste

About 45 truck loads per year of solid wastes will be shipped from the station to a disposal site.* Under normal conditions, the individual truck driver might receive as much as 15 mrem per shipment. If the same driver were to drive 25 truck loads per year, he would receive an estimated annual exposure of about 400 mrem (maximum permissible exposure for radiation worker is 12,000 mrem per year.) The total exposure of all drivers for the year, assuming 2 drivers for each shipment, might be as much as 1.4 man-rem.

If a person were near the truck for a few minutes at an average distance of 3 feet, he might be exposed to as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 45 shipments would be about 0.6 man-rem. The staff has estimated that the distance to the waste storage site is 500 miles.* Based on this number of miles and the average population density in the eastern part of the country, a staff derived number of people along the route is 150,000 persons. The dose to these people caused by the transport of radioactive waste from the site to the waste disposal area is about 0.6 man-rem. This is less than natural background (100 mrem per year or 15 man-rem). These doses were calculated for persons in an area between 100 feet and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10mr/hr at 6 feet from the vehicle, and the shipment traveling 200 miles per day.

F. ENVIRONMENTAL MONITORING

1. Radiological

The environmental monitoring program is designed to provide direct measurement of the environmental doses that result from the radioactive releases from the plant. Experience gained in conducting to

*The applicants have not indicated a disposal site so these exposures are based on an estimated average distance from the station to the waste disposal area.

the monitoring program at Dresden Unit I was used to develop the Quad-Cities program.

The applicants began pre-operational monitoring surveys in 1968 to determine natural background levels of radioactivity in the area of the Quad-Cities Station. Samples of air, water, milk, grass, cattle feed, vegetation, surface (river) water, bottom sediment, slime, soil, and fish have been analyzed. The analyses included gross alpha and beta activities, gamma spectra, tritium, Sr-89, -90, Cs-137, and I-131. The results provide a background measurement which will make it possible to distinguish between radioactivity introduced into the environment by plant operation and that introduced from other sources.

The applicants' post-operational program is basically a continuation of the pre-operational program and is presented in the Environmental Report.[23] The monitoring program will detect changes in the environmental radioactivity; both transient fluctuations and long-term accumulations. The details of the monitoring program will be included in the Technical Specifications which are issued with any operating license.

2. Non-Radiological

Bio-Test has prepared a "Study Plan for Determination of Thermal Effects in the Mississippi River-Quad-Cities Station"[67] for the applicants on the basis of the program which produced the first two reports.[36,37] The purpose of the study plan, which is essentially an intensification of former studies, is to continue on a more specific basis the evaluation and definition of the physical, chemical, and biological conditions that exist in the Mississippi River in the vicinity of the station prior to plant start-up, after start-up on Unit 1, and after both units are operational. The proposed program consists of nine projects:

(1) Literature Review,

(2) Temperature and Dissolved Oxygen Monitoring,

(3) Water Quality Evaluation at Quad-Cities Station,

(4) Pesticide Analyses at Quad-Cities Station,

(5) Temperature Response of Fish and Plankton,

(6) Artificial Substrate Studies of Periphyton and the Macroinvertebrate Community,

(7) Thermal Effects Program at Quad-Cities Station,

(8) Fish Population and Life History Study, and

(9) Thermal Effects Program at Riverside Generating Station.*

The staff evaluated the proposed program and discussed its implementation with the applicants. By virtue of these discussions, discussions with state conservation officials of Iowa and Illinois, as well as the hearings before both the Iowa Water Pollution Control Commission and the Illinois Pollution Control Board changes were made in the depth of some of the projects.

The staff believes the current program is adequate to detect any widespread biological changes that may occur downstream from plant operation. The details of the monitoring program including limiting conditions, reporting requirements, etc., follow the guidance of this Final Environmental Statement and are described in the Technical Specifications.

G. STATION DISMANTLING AND DECOMMISSIONING

Under the Commission's regulations in 10 CFR 50, an application must contain information sufficient to demonstrate that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the station down and maintaining it in a safe condition.

1. Non-Radiological Impacts on the Environment

Dismantling the station will have many of the same impacts on the environment as the original site preparation and station construction. There will be temporary disturbances due to the dismantling activities and the permanent restoration of most of the site to ecological productivity.

*This is a continuation of a program already in existence[6] at the Davenport, Iowa, Riverside Generating Station.

The overall impact of dismantling the station will be beneficial to the environment, since the objective of that proposed action is to restore most of the station's acreage to ecological productivity. It is estimated that less than 10 acres will not be useable after dismantling.

2. Radiological Impacts on the Environment

The dismantling of the station will have radiological impacts characteristic of transporting from the site irradiated fuel and radioactive wastes. See Section V.E.

The radioactive materials not transported offsite will be entombed with the reactor and associated components. The entombment will be designed to maintain its integrity for more than 100 years, to provide time for radioactive decay of activated and fission products. In addition, the entombment will be permanently placarded to identify it.

Under the terms of a dismantling license that may be issued by the Commission and with the funds necessary to cover the estimated costs of permanently shutting the station down and maintaining it in a safe condition, it is expected that the proposed action will have no significant radiological impact on the environment.

VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. STATION ACCIDENTS

Protection against the occurrence of postulated design basis accidents in the station is provided through the defense in depth concept of design, manufacture, operation and testing, and the continued quality assurance program used to establish the necessary high degree of assurance for the integrity of the reactor primary system. These aspects were considered in the Commission's Safety Evaluation[1] for the station. Off-design conditions that may occur are limited by protection systems which place and hold the power plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, even though unlikely; and engineered safety features are installed to mitigate the consequences of these postulated events.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions were used for the purpose of evaluating the adequacy of engineered safety features and for comparing calculated doses resulting from a hypothetical release of fission products from the fuel against the 10 CFR Part 100 siting guidelines. The computed doses that would be received by the population and environment from actual accidents would be significantly less than those presented in the Safety Evaluation.[1]

The Commission issued guidance to applicants,[2] requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicants' response was contained in the Supplemental Information to the Quad-Cities Environmental Report.[3]

The applicants' report has been evaluated, using the standard accident assumptions and guidance proposed by the Commission.[4] Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious have been identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a very low occurrence rate, and those on the low potential consequence end are characterized by a higher occurrence rate. The examples selected by the applicants for these classes of accidents are shown in Table 15. The examples given are reasonably homogeneous in terms of probability within each class.

TABLE 15

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

No. of Class	AEC Description	Applicants' Examples
1	Trivial incidents	None
2	Small releases outside containment	Reactor coolant leaks (below or just above Technical Specifications limits outside PC or RB).
3	Radwaste system failures	Any single equipment failure or any single operator error.
4	Fission products to primary system (BWR)	Fuel failures during transients outside the normal range of plant variables but within expected range of protection equipment and other parameter operation.
5	Fission products to primary and secondary system (PWR)	Primary coolant loop to auxiliary cooling system secondary side of heat-exchanger leak.
6	Refueling accidents	Dropping fuel assembly on reactor-core, spent fuel storage rack, or against pool boundary; dropping spent fuel shipping cask in pool or outside pool.
7	Spent fuel handling accident	Transportation incident involving spent fuel shipment on-site but outside PC or RB.

TABLE 15 (continued)

No. of Class	AEC Description	Applicants' Examples
8	Accident initiation events considered in design basis evaluation in the Safety Analysis Report	Reactivity transient, loss of reactor coolant inside or outside primary containment.
9	Hypothetical sequences of failures more severe than Class 8	None

Certain assumptions made by the applicants, such as the assumption of an iodine partition factor in the suppression pool during a loss of coolant accident and the efficiency assigned to the charcoal filters in the standby gas treatment system, in our view, are optimistic; but the use of alternative assumptions does not significantly affect the overall environmental risk.

Commission estimates of the dose which might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex,[4] are presented in Table 16. Estimates of the integrated exposure in man-rem that might be delivered to the population within 50 miles of the site are also presented in Table 16. Although the applicants' estimates were based on the 1970 population density figures, the man-rem estimates presented in Table 16 were based on the projected population around the site for the year 2010.

To rigorously establish a realistic annual risk, the calculated doses in Table 16 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operation and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures, the events in Classes 3 through 5 are not anticipated during plant operation; but events of this type could occur sometime during the 40 year plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table 16 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered for the design basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture, and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

TABLE 16

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS TO THE QUAD-CITIES NUCLEAR POWER STATION UNITS 1 and 2 AT RATED POWER AS DETERMINED BY THE AEC

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary[a/]	Estimated Dose to Population in 50 mile Radius, man-rem
1.0	Trivial incidents	b/	b/
2.0	Small releases outside containment	b/	b/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.29	10
3.2	Release of waste gas storage tank contents	1.1	40
3.3	Release of liquid waste storage tank contents	0.001	<0.1
4.0	Fission products to primary system (BWR)		
4.1	Fuel cladding defects	b/	b/
4.2	Off-design transients	0.012	1.0
5.0	Fission products to primary and secondary systems (PWR)	N.A.	N.A.

a/ Represents the calculated whole body dose as a fraction of 500 mrem (or the equivalent dose to organ).

b/ These releases will be comparable to the design objective indicated in the proposed Appendix I to 10 CFR Part 50 for routine effluents (i.e., 5 mrem/yr to an individual from either gaseous or liquid effluents).

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary[a]	Estimated Dose to Population in 50 mile Radius, man-rem
6.0	Refueling accidents		
6.1	Fuel bundle drop	<0.001	<0.1
6.2	Heavy object drop onto fuel in core	0.002	0.73
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	<0.001	0.16
7.2	Heavy object drop onto fuel rack	<0.001	0.30
7.3	Fuel cask drop	0.42	15
8.0	Accident initiation events considered in design basis evaluation in the safety analysis report		
8.1	Loss-of-coolant accidents		
	Small break	<0.001	<0.1
	Large break	0.002	9.9
8.1(a)	Break in instrument line from primary system that penetrates the containment	<0.001	<0.1
8.2(a)	Rod Ejection Accident (PWR)	N.A.	N.A.
8.2(b)	Rod drop accident	0.014	1.2
8.3(a)	Steamline Breaks (PWR-outside containment)	N.A.	N.A.
8.3(b)	Steamline breaks (BWR)		
	Small break	0.01	0.35
	Large break	0.051	1.8

[a] Represents the calculated whole body dose as a fraction of 500 mrem (or the equivalent dose to organ).

[b] These releases will be comparable to the design objective indicated in the proposed Appendix I to 10 CFR Part 50 for routine effluents (i.e., 5 mrem/yr to an individual from either gaseous and liquid effluents).

The information given in Table 16 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials within or comparable to the Maximum Permissible Concentrations.[6] The tabulated information also shows that the estimated integrated exposure of the projected population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from the naturally occurring radioactivity. The exposure from naturally occurring radioactivity corresponds to approximately 2200 man-rem per year within 5 miles and approximately 244,000 man-rem/yr within 50 miles of the site. These estimates are based on a natural background level of 0.14 rem/yr. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents at the station are exceedingly small and need not be considered further.

B. TRANSPORTATION ACCIDENTS

This section has been based on information from the same study referred to in Section V.E., which has been adapted to the station.

1. Exposures Resulting from Postulated Accidents

A discussion of the materials to be transported is given in Section III E.

a. Non-irradiated Fuel

Under accident conditions other than accidental criticality, the pelletized form of the uranium fuel, its encapsulation, and the low specific activity of the fuel limit the radiological impact on the environment to negligible levels. Even for the higher radioactivity of plutonium recycle fuel, the form and encapsulation under credible accident conditions would limit the radiation effects on the environment to negligible levels.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel elements under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which is unlikely to happen in other than an extremely severe accident.

The probability that an accident could occur under conditions that could result in accidental criticality is remote, based on staff calculations. In the highly unlikely event that criticality were to occur in a transport accident, persons within a radius of about 100 feet from the accident might receive a serious exposure but, beyond that distance, no detectable radiation effects would be likely. Persons within a few feet of the accident could receive fatal or near-fatal exposures unless shielded by intervening material. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 feet. There would be very little dispersion of radioactive material.

b. Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel were estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

(1) Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. On the basis of staff calculations, such an accident is unlikely during the 40-year life of the plant.

Leakage of liquid at a rate of 0.001 cc per second or about 80 drops/hour can usually be detected by visual observation of a large container. If leakage of contaminated liquid coolant were to occur and should go undetected, the amount would be so small that the individual exposure would not exceed a few mrem and only a very few people would receive such exposures.

(2) Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel elements penetrated, some of the coolant and some of the noble gases might be released from the cask. The probability of occurrence of such an accident is considered to be extremely remote.

In the highly unlikely event that such an accident were to occur, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[5] of the Environmental Protection Agency.

c. Solid Radioactive Wastes

About 45 truckloads of solid radioactive wastes will be transported each year from the station to a disposal site. The likelihood that radioactivity would be released as a result of waste being involved in an accident, lids on drums coming off, and some of the waste material getting outside of the drum is very small.

It is highly unlikely that a shipment of waste will be involved in a severe accident during the 40-year life of the plant. If it does happen that a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant.

Other solid waste from the station will be shipped in Type B packages, according to the applicants. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

In either unlikely event, spread of the contamination beyond the immediate area is unlikely and, although local clean-up might be required, no significant exposure to the general public would be expected to result.

2. Severity of Postulated Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and their consequences could be severe. Quality assurance for design, manufacture, and use of the packages, continued surveillance and testing of packages and transport conditions, and conservative design of packages insure that the probability of accidents of this latter potential is small. On the above bases we conclude that the risk of adverse effect to the environment due to transportation accidents is extremely low.

VII. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

A. LAND USE

Station construction, site grading and spoil banks have changed the land contour on nearly half of the 560 acre site. The soil in the site is quite sandy so that siltation from runoff should be minimal. Installation of the diffuser-pipe system and the spray canal will add more spoil although the excavation from the spray canal will to a large extent be used for dikes along the canal. Drainage control, grading and seeding will avoid significant siltation into the river. Grasses are already growing on the spoil banks and regraded fill.

Although the site is out of agricultural productivity, its use is consistent with the industrial park development to the north. The land, with the probable exception of that portion occupied by the reactors, could be returned to agricultural usage. An additional quantity of farmland is traversed by the 125 miles of new transmission lines. Of this quantity, the applicants report that about 45 miles were required regardless of whether the Quad-Cities station was built. The right-of-way for the transmission lines can be and is frequently used for agricultural purposes so that the loss of agricultural productivity is relatively small. The applicants reported that forest was removed along 0.4 mile of the right-of-way.

The operation of the station will result in the generation of steam fog and/or freezing steam fog, or enhancement of natural steam fog. This is most likely to occur when the spray-canal is in operation but may also occur during operation of the side-jet. It is possible that the steam fog will result in lack of visibility and icing along the highway and railroad. Present limited experience indicates that steam fog is not likely to be a serious problem.

The installation of the spray canal will affect adversely those small organisms living in the earth. This should have an insignificant effect on the general area surrounding the station.

B. WATER USE

The station, when operating at full capacity and using diffuser-pipe system, will heat 2270 cfs of Mississippi River wastes about 23°F higher than the intake temperature. The present construction schedule for the spray-canal calls for one of the station units to be on the closed cycle by May of 1974 and the second to be on closed cycle operation one year later. Thus by May 1974 the river water heated 23°F will be decreased to about 1160 cfs and by May 1975 the heated water returned to the river should be about 50 cfs.

With the side-jet in operation, the warm water discharged, to a large extent, was expected to flow along the Illinois shore and subject the sloughs in and around a small group of islands to water temperatures 5-20°F above normal.

The installation of the diffuser-pipe system caused some siltation during the construction operation. This will have local adverse effects on benthic organisms. This should affect only a small fraction of Pool 14. Repopulation of benthic organisms is expected to occur from downstream drift.

The operation of the station with the diffuser-pipe as proposed is not expected to have an overall effect on the aquatic life in Pool 14. It is likely to have some local effects due to entrainment of organisms in the condenser cooling water and the impact of the warm water on the organisms in the vicinity of the discharge jets. These organisms are expected to be unaffected outside of the discharge area (i.e., 600 feet). A small amount of water will be evaporated (∿0.1 percent of the average annual flow).

The spray-canal operation will have an average water makeup from the river of 100 cfs and an average blowdown of 50 cfs. The blowdown quantity will have the same dissolved material as found in the river with the concentration increased by a factor of about two. This concentration is, however, not in excess of that allowed under existing standards. The water lost by evaporation will also average at about 50 cfs which approximates the same quantity when the diffuser-pipe system is used.

The station will discharge small amounts of chemicals into the river. These chemicals are diluted enough to assure protection of the aquatic biota. This will be carefully monitored to assure that there are no adverse effects on the environment.

C. BIOLOGICAL IMPACT

Fish may congregate in the intake canal in search of food, cover, or spawning areas resulting in damage due to crowding, contact with the screens or entrainment of young. Entrained organisms will be exposed to mechanical, thermal, and chemical effects while flowing through the condenser. Fish and other aquatic biota may be adversely affected by the discharged warm water or residual chlorine. These stresses could affect the species compositions of the discharge area. It is anticipated that the aquatic communities will be able to tolerate these impacts and reestablish, if necessary, a normal community structure once the spray-canal is installed and the diffuser-pipe discharges are terminated or reduced in magnitude. A monitoring program will detect any major effects on the environment of Pool 14 so that remedial action can be taken.

D. RADIOLOGICAL IMPACT

There will be a low level risk of accidental radiation exposure to the residents at the site vicinity. This risk and the associated impact are considered a small contribution to the natural background. Similarly, the routine radioactive liquid and gaseous wastes emitted are in quantities too small to produce a measurable effect on the environment.

E. TRANSPORTATION IMPACT

There will be a low level risk of radiation exposure due to the normal transport of nuclear materials, new fuel, irradiated fuel, and radioactive wastes. Accidents during transportation of these materials are possible, though unlikely. These postulated accidents are not likely to add appreciably to the total radiation dose to the public and, in any case, are not likely to spread contamination beyond the immediate area.

VIII. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The existence of the station has removed 560 acres from residential and agricultural usage. The site as acquired by the applicants had about 100 acres planted with evergreens. The installation of the spray-canal will require removal of some of these trees. That portion of the site which was removed from active agricultural use is too small to have a noticeable impact on the regional base. In addition, the conversion from residential and agricultural usages to industrial usage is consistent with the industrial area to the north of the site.

The applicants have made the commitment to change the condenser water cooling system from a side-jet discharge to a diffuser-pipe system and finally to a closed-cycle spray canal. The side-jet operated until August 2, 1972, the diffuser is scheduled to operate until May 1, 1975, and the spray-canal thereafter. With the side-jet operation, the productivity of the river in the shallow areas along the Illinois shore and downstream past a small group of islands may have been decreased due to the warmed and chlorinated waters. This effect should decrease with the diffuser-pipe in operation because the warm waters are discharged into the river's main channel which is a less productive zone, because the diffuser-pipe system provides a lesser warm zone due to the rapid mixing and, finally, because the longer holdup time for the condenser system should allow the free chlorine to decrease before mixing with the river water. With the spray-canal operating, there should be an unmeasurable effect on the river due to condenser operation.

The overall productivity of Pool 14 is not expected to be significantly changed. Since the most adverse of the condenser operating conditions are short term, the river is expected to recover from whatever adverse effects may occur.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction and operation of the station will result in some irreversible or irretrievable commitments of resources, in terms of local environmental impacts and consumption of materials representing natural resources. The commitments through local impacts are essentially limited to the land occupied by the station and the evaporative losses incurred from operation of the spray-canal. These commitments are reversible in the long term. The station can be dismantled with the necessary expenditure of money. Upon cessation of operation, the local commitment of water loss from the spray-canal ceases.

Resources include land, water, air, and the products thereof, such as minerals, flora, and fauna, which are the ingredients of goods, services, and food. While reversibility and retrievability can be intrinsic properties of any resource commitment, there is also a factor of practicability to consider - namely, that to reverse or retrieve such a commitment could require an inordinate amount of human effort in time and money or alternately more than a single generation by nature itself. In such, the commitment, for practical purposes, is irreversible and irretrievable.

The following resources are committed in regard to the environmental components of land and water.

1. Land committed for the station components themselves. The reversibility is a question of time and money. As long as the station is operable, the land is productive in the generation of electricity for beneficial use. The commitment of the land for the station precludes its use, however small the acreage, from agriculture or other purposes. To the extent that some components of the concrete structure and equipment become radioactive, they may become in essence, irretrievable due to the practical aspects of reclamation, radioactive decontamination, or both. Under the Commission's regulations in 10 CFR Part 50, an application must provide information sufficient to demonstrate that the applicants possess or have reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the station down and maintaining it in a safe condition.

2. Water consumed by operation of the spray-canal is a minor local loss to the Mississippi River. Through natural phenomena this water will return to the surface of the land as a form of precipitation.

3. The nuclear fuel is a resource irreversibly committed in the construction and operation of the station and, to the extent that the reactor building is not completely demolished, that small amount of land committed to non-productive use.

The staff concludes that the irreversible and irretrievable commitments are appropriate for the benefits gained.

X. NEED FOR POWER

The station is one-quarter owned by the Iowa-Illinois Gas and Electric Company and three-quarters by the Commonwealth Edison Company. Iowa-Illinois Gas and Electric Company serves a region covering parts of Rock Island and Henry Counties in Illinois, Scott County in Iowa, and territory surrounding and including Fort Dodge in north central Iowa, and Iowa City in eastern Iowa. The Commonwealth Edison Company serves most of the northern part of Illinois excluding a small territory in the northwestern part of the state. The Commonwealth Edison Company has a firm commitment to Northern Indiana Public Service Company which has Lake and Porter counties of Indiana in its operating territory. These two Indiana counties include the heavy industrial area of northwestern Indiana directly adjacent to Illinois.

For summer of 1972, the Commonwealth Edison Company estimates its peak load at 12,600 MW* based on average temperature conditions. If the summer is warmer than average the peak load could increase by 300 to 400 MW.

Without the station units (see tables 17 and 18), the Commonwealth Edison Company's capacity, including firm purchases from other utilities, will be 13,552 MW which provides a reserve of approximately 952 MW or 8.1 percent.**

This estimate is a little over one-fourth of the amount recommended by the Federal Power Commission and is well below Commonwealth Edison Company's normal target of 14 percent and the higher 1972 reserve levels which had been projected. The 952 MW reserve is less than the capacity of each of two presently operating units on the Commonwealth Edison Company's system and is very little more than the capacity of each of five other units. A malfunction which causes the shutdown of any one of these units would cancel the reserve.

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*MW represents megawatts electrical for this section.

**This assumes completion of Powerton 5, an 840 MW fossil-fuel-fired unit still under construction. While the Commonwealth Edison Company expects this unit to be in service for the summer, the reliability of new large coal-fired units has been poor.

TABLE 17 COMMONWEALTH EDISON COMPANY STATEMENTS FOR LOAD AND CAPACITY FOR PEAK PERIODS OF 1972-75 [(a)]

(In Megawatts)

	1972	1973	1974	1975
Owned Capability	14025**	16122	16172	16046
Less - Summer limitations	281	333	333	327
Plus - Firm Purchases & Diversity Exchange	900	200	1324*	1324*
Net Capability	14644	15989	17163	17043
Load				
Estimated Peak Load	12190	12830	13880	14990
Plus Firm Sales	410	60	410	100
Est. Total Peak Load	12600	12890	14290	15090
Reserve				
Reserve Margin	2044	3099	2873	1953
Percent Reserve	17.5	24.4	21.1	13.6

*Includes 624 MWe purchase from the Ludington Pumped Storage Project in Michigan.

**Includes Joliet #1-#4 (60 MWe), Quad Cities #1 and #2 with 90% of full capacity (1,092 MWe-CECo portion)
Does not include Zion #1 (1,050 MWe).

TABLE 18 CAPACITY PROGRAM - COMMONWEALTH EDISON COMPANY

	Capacity MW	Projected Service Date[a]
Additions		
Dresden 3	809	Oct. 1971
Quad Cities 1	405[b]	Dec. 1971[c]
Quad Cities 2	809	March 1972[c]
Powerton No. 5	840	May 1972
Zion No. 1	1050 50	Aug. 1972 April 1973
Zion No. 2	1050 50	May 1973 Nov. 1973
Retirements		
Fordam 1-10	72	Oct. 1971
Joliet 1-4	60	Oct. 1972
Waukegan 1-3	101	Oct. 1972
Powerton 1-2	126	Oct. 1974

(a) Based on construction as scheduled.
(b) Commonwealth Edison Company portion.
(c) As of August 15, 1972 these units are available at 90 percent of rated power.

A 952 MW reserve, 8.1 percent, is inadequate. This is evident from Commonwealth Edison Company's recent experience as well as by comparison with Federal Power Commission recommendations. On the peak load day of 1970, the Commonwealth Edison Company had 1664 MW of forced outages and restrictions. On the peak day of 1971, this number was 2239 MW. Owing to deferring of maintenance, this number is more likely to grow than to decline. Subtracting 1664 and 2239 from the projected reserve of 952 MW yields a deficit in the range of 700 to 1300 MW. According to the applicants4 almost no additional firm power can be purchased to make up this deficit. Emergency power from other systems has allowed the Commonwealth Edison Company to meet its peak loads in the last several years. However, emergency power in the large amounts required is not likely to be available in 1972.

The Iowa-Illinois Gas and Electric Company service area consumption is projected to increase from 2.5 billion kwhr in 1970 to 22.6 billion kwhr in the year 2000. The Commonwealth Edison Company service area projections are from 45.8 billion kwhr in 1970 to 404.9 billion kwhr in 2000.

The Iowa-Illinois Gas and Electric Company predicted a 1972 summer peak of 714 MW. The 404 MW Iowa-Illinois Gas and Electric Company allocation from the station will represent about 40 percent of their system capacity at that time (see Table 19). Without the station, Iowa-Illinois Gas and Electric Company projected a system deficit of over 100 MW.

The Iowa-Illinois Gas and Electric Company is interconnected with other electric companies around it and is a member of the Iowa Pool. This pool is a formal organization of six utilities in Iowa which serves most of the electric load in the State. The members of this pool plan load and capacity requirements together (Table 20) and these plans count on 404 MW from the station to maintain a 12 percent installed reserve in the reserve in the summer of 1972.

Both the Iowa-Illinois Gas and Electric Company and the Commonwealth Edison Company are members of Mid-America Interpool Network (MAIN), an association of electric power companies in the Midwest. Through the MAIN Coordinating Center, full use is made of the facilities in the region to provide emergency assistance to a system experiencing difficulties supplying its load.

TABLE 19 IOWA-ILLINOIS GAS AND ELECTRIC COMPANY
LOAD AND CAPACITY FOR PEAK PERIODS

(In Megawatts)

	1972	1973
Load	714	767
Reserve Required (12%)	86	92
Total Responsibility	800	859
Existing Generation	594	594
Quad-Cities (Summer Rating)	394	394
Retirement	(10)	(10)
Net Generation	978	978
Participation Sales (Based on Quad-Cities Station in service)	136	80
Net Capacity	842	898
Excess over 12% Reserve	42	39
Deficiency without Quad-Cities	(206)	(265)

TABLE 20 IOWA POOL LOAD AND CAPACITY FOR PEAK PERIODS

(In Megawatts)

	1972	1973
Load	3125	3379
Net firm Purchase or Sale	182	(25)
Net Demand	2943	3354
Reserve Required	356 (12%)	503 (15%)
Total Responsibility	3299	3857
Total Generation	3332	3322
Net Participation Purchase	23	540
Total Capacity	3355	3862
Surplus	56	5
Deficit without Quad-Cities Station	(282)	(897)(a)
Deficit without Quad-Cities Station and Neal No. 2 delayed 6 months	(622)	

(a) Based on delay of Quad-Cities, Cooper, and Ft. Calhoun nuclear units.

Relative to the MAIN reserve situation the Federal Power Commission comments on the Draft Environmental Statement (see Appendix A) dated March 22, 1972 includes the following. "The December 20, 1971 report of the FPC Bureau of Power included this analysis, and it indicated a reserve margin for the MAIN area of only 8.9 percent without the Quad-Cities and Zion Units. This becomes 8.1 percent if the 224-megawatt reduction of Commonwealth Edison capacity heretofore noted is subtracted. Also of great importance are the seven large fossil-fueled units in the MAIN area included in the capacity resources which have suffered some delays and are not now expected to be in commercial operation until May and June 1972. These units and their sizes are: Cayuga 2 - 500 megawatts, Edwards 3 - 350 megawatts, Coffeen 2 - 600 megawatts, Powerton 5 - 840 megawatts, Neal 2 - 321 megawatts, Labadie 3 - 555 megawatts, and New Madrid 1 - 600 megawatts. Recent experience with large new units has indicated a relatively high degree of unavailability during initial service periods, with a consequent added threat to the adequacy and reliability of electric service. Also included in the area capacity are two other nuclear units, the operating 497-megawatt Point Beach 1 and the not yet operating 497-megawatt Point Beach 2. Because of the logistics of current licensing procedures, the latter unit may not be available for the 1972 summer peak. Excluding the two Quad-Cities units, the seven fossil-fueled units and the Point Beach No. 2 unit, not yet in operation, total 4,263 megawatts of new capacity which was included in the originally-planned summer 1972 total."*

The applicants have stated, with supporting submissions,[1,2,3,4] that electric service in Chicago, Northern Illinois, and all of Iowa will be seriously jeopardized if the Quad-Cities generating capacity is not available to meet the 1972 summer peak load.

The Federal Power Commission commented[5] on the above situation in early 1971 as follows:

"While the amount of reserve capacity which individual systems consider necessary varies from system to system, a reserve of about 20 percent is generally regarded as sufficient for most moderately sized systems."

*All of the fossil units mentioned in this paragraph have been synchronized into their utility systems. All are experiencing startup problems. Point Beach 2 will not be available for the summer of 1972.

"Under normal circumstances, alternate means for providing need capacity might have included importation of power from neighboring systems, the construction of a fossil fuel generation station or a hydroelectric installation. In the case of the Quad-Cities Nuclear Units, however, the imminence of a potential bulk power supply crisis in 1971 and 1972 rules out all alternatives in our opinion, even the alternate of importation of power, which must be considered as impracticable because of the lack of excess reserves in any of the areas within economical transmission distance from the systems of the applicants'."

"In view of the foregoing, it is evident that the need for the power from the Quad-Cities units is a clear and pressing issue with regard to reliability of bulk power supply on the systems of the Commonwealth Edison Company and the Iowa-Illinois Gas and Electric Company."

The situation which faces the applicants currently is the subject of a staff report[6] by the FPC's Bureau of Power which was transmitted to the Atomic Energy Commission. In its report, the FPC views the situation as a potential supply shortage throughout the midwest and concludes with the following:

"The Bureau of Power Staff is of the opinion that the criterion of 14 percent reserves in the MAIN pool may be low. System reserves are affected by a number of factors, including system size, the sizes and types of generating system load characteristics, system maintenance practices, and interconnection transfer capabilities."

"The staff considers the additional capacity of 1,618* megawatts from the Quad-Cities Station necessary to bolster the existing system reserves on the Commonwealth Edison Company's and the MAIN's systems and the Iowa-Illinois Gas and Electric Company's and the Iowa Pool's systems at the 1972 summer peak. Recent experience on other systems indicates it is not unlikely for two new large units to be forced out of service during the same critical period. The Quad-Cities Station operating at full rated power would provide an additional 1,618* megawatts of capacity during the 1972 summer peak which might avert system catastrophe under many possible emergency conditions."

"The factors examined indicate that there is an emergency need for interim operation of the Quad-Cities Units 1 and 2, assuming that

*When the spray-canal is operable, the station is to be rated at 1600 MWe.

the AEC can concurrently deal appropriately with environmental issues involved in such operation. In addition to the factors analyzed in the original and supplemental environmental studies dealing with partial operation of this plant, the potential consequences of not having sufficient electric power in this system and region, for the reason outlined above, would include inability to meet important power needs for residential, commercial and industrial customers."

"The applicants report that they have an investment of $193 million in plant and fuel and that net costs of replacement power, assuming that it is available, will be $1,200,000 per week for each week of delay in the availability of the Quad-Cities Units 1 and 2. The staff has examined this cost and the relative order of magnitude of added production costs have been found to be reasonable."

More recently[10] the FPC has reported the latest reliable information on anticipated loads and operating capacity for Northern Illinois, Wisconsin and Upper Michigan. For the summer of 1972 the situation is as follows:

	A	B
Net Capability, MWe	21,122	20,018
Peak Load MWe	18,414	18,414
Reserve, MWe	2,708	1,604
Reserve, Percent of Peak Load	14.7	8.7

A. With Quad-Cities, Units 1 and 2, at a combined capacity of 809 MW due to cooling limitations, and Point Beach 2.*

B. Without Quad-Cities, Units 1 and 2, or Point Beach 2* (Note that half the capacity of Quad-Cities Unit 1 is committed to the Iowa Pool.

The FPC states in the above report,

*Point Beach 2 will not operate in the summer of 1972.

"It is clear that without these plants, the adequacy of power in the summer of 1972 will depend critically upon unscheduled outages and the availability of power from neighboring areas, especially the East Central area."

The FPC concern is shared by the National Electric Reliability Council. In a recent report by a subcommittee of the Council's Technical Advisory Committee,[7] it is noted that:

"Although a regional reserve level of approximately 15 percent for the summer of 1972 may appear adequate in light of past experience, the major impact of delays in nuclear operation will be in the Chicago area where reserves of Commonwealth Edison Company (CE) drop from 23.5 percent to 5.4 percent. Under these conditions, over 1,000 MW firm replacement power would be necessary to provide acceptable levels of electric service reliability. This amount of power is not available on a firm basis. Furthermore, at times when this power may be available from systems south of Chicago, such transfer of power would severely burden the transmission system in that area and restrict its use for short term emergency assistance which unexpected and unplanned outages of generation and transmission will require."

The Illinois Commerce Commission emphasized the urgent need for additional generating capacity in a recent letter to the AEC,[8] which stated:

"It is apparent that Illinois must put into operation some of the capacity now under construction before next summer or face the certainty of power outages. The units most able to contribute to the required capacity are Edison's Quad-Cities 1 and 2, because they are ready for testing and operating."

Mr. Ayers, president of Commonwealth Edison Company, has apprised[4] Chairman Schlesinger of the seriousness of the power shortage with supporting data and the urgency of interagency coordination to obtain a solution to the problem of obtaining power from the station.

The applicants state that every megawatt not produced at Quad-Cities will have to be produced by the oldest, most inefficient coal-fired units on the applicants' systems. Such generation is estimated to result in adding about 70 pounds of sulfur dioxide and 3 pounds of particulates per megawatt-hour to the environment. The Illinois Pollution Control Board, in granting a variance from air particulate regulations for operation of several coal-fired units which are to be retired upon completion of Quad-Cities Unit 1, stated, "The present petition underlines the importance of placing Quad-Cities in use at the earliest date."[9]

XI. ALTERNATIVES TO PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF THEIR ENVIRONMENTAL EFFECTS

The applicants have provided a discussion of alternatives and a cost-benefit analysis in their Environmental Report Supplement.[1] The staff's independent review is summarized below. In many cases, the staff found the applicants' estimates adequate and these were used in the analysis. In other cases, estimates were made independently.

A. SUMMARY OF ALTERNATIVES

The need for power for the applicants' region was discussed in detail in Section X. If the station were abandoned or delayed, the applicants would not be able to meet projected power demands. Although environmental factors were not considered in detail in selection of the Quad-Cities site, its location is not, in general, unfavorable and is consistent with plans for that area. Since construction of the station is nearly complete, environmental impacts associated with occupancy of the site have already been incurred. If the station site were not used and another were selected for a power plant, most of these impacts would be duplicated. Also, costs of purchased replacement power during construction at another site would be large.

The applicants have provided a detailed discussion of nine* alternatives.[1] These are:

(1) present design with currently planned diffuser system and additional radwaste modifications,

(2) mechanical draft cooling tower,

(3) natural draft cooling towers,

(4) spray cooling

(5) cooling lake,

(6) mechanical draft towers with modified radwaste system,

(7) fossil fuel units at the Quad-Cities site,

(8) delay of operation of the station, and

(9) abandonment of the station.

*This does not include the diffuser-pipe as an alternative.

The applicants' consideration and analysis of these alternatives appear to be adequate. These are summarized in Table 21 and 22 and in Section B below. The applicants have proposed to complete modifications of the radwaste system by the end of 1973. They have built a diffuser-pipe and also have agreed to install a spray-canal which is to be completed by May 1, 1975.

B. SUMMARY OF COST-BENEFIT ANALYSIS

During the process of the NEPA review, which began with the receipt of the applicant's Environmental Report on November 12, 1970, several changes were made which involved the alternatives listed above. They are summarized briefly here:

Condenser Cooling System Changes

The original wing-dam discharge system was replaced, first by a temporary side-jet, later by a semi-permanent diffuser-pipe and still later by a yet-to-be constructed spray-canal system. These changes were made to reduce the total impact on the quality of the environment (see Table 23). The change to the spray-canal will represent a greatly reduced impact on the quality of the environment due to the thermal effluent.

Radwaste System Changes

The applicants have agreed to install a modified gaseous radwaste system and a maximum recycle liquid radwaste system. These systems will reduce the radioactive effluents significantly as indicated in Table 23.

1. Land Use

About 560 acres of agricultural land have been converted to industrial use, although only about 100 acres are occupied by operating facilities of the station. Much of the remaining 460 acres will be required for the spray canal. The station is in the vicinity of other existing and planned industrial activities. About 125 miles of transmission lines were constructed across agricultural and some wooded land with a small environmental impact.

2. Water Use

During construction of the station, the Mississippi River was dredged for placement of cooling system components. Additional dredging was

TABLE 21[1] RELATIVE MAGNITUDE OF ENVIRONMENTAL CHANGES

II. Environmental Characteristics and Conditions	I. Quad Cities Alternatives						
	1. Present System With Jet Diffuser	2. Mechanical Draft Cooling Towers	3. Natural Draft Cooling Towers	4. Spray Canal	5. Cooling Lake*	6. Mechanical Draft and Ultimate Radwaste*	7. Fossil-Fueled Plant
A. Physical and Chemical							
1. Earth	E	D	D	E	E	D	D
2. Groundwater	E	E	E	D	C	E	E
3. Ponds and Lakes	E	E	E	E	E	E	D
4. Rivers and Streams	C	D	D	D	D	D	C
5. Atmosphere	D	C	C	C	C	C	C
B. Biological Conditions							
6. Terrestrial	E	D	D	D	D	D	E
7. Aquatic	B	D	D	D	D	D	B
8. Atmosphere	E	D	C	E	E	C	E
C. Land-Use Patterns							
9. Undeveloped Areas	D	D	D	D	C	D	D
10. Developed Areas	B	B	B	B	B	B	B
D. Cultural							
11. Esthetics	C	B	A	C	(B)**	A	B
12. Health and Safety	D	C	D	C	D	D	D
13. Interactions with Man-Made Facilities	E	D	D	D	B	D	C

*Values in this table were assigned without regard to the technical feasibility of the alternative.

**Indicates a beneficial change.

Relative Magnitude of Impacts

- A Major change in environmental condition
- B Moderate change in environmental condition
- C Minor change in environmental condition
- D Probably less than C but no information on which to base estimate
- E No change anticipated.

Table 22[1] Summary of Regional Environmental Conditions, Costs and Other Considerations

Quad Cities Site Specific Environmental Characteristics	Environmental Components and Parameters	Present Quad Cities Environment	Alternatives I Present Plant Design With Jet Diffuser System	II Mechanical Draft Cooling Tower	III Natural Draft Cooling Towers	IV Spray Cooling	V Cooling Lake	VI Mechanical Draft Cooling Towers With Ultimate Radwaste Treatment System[a]	VII Fossil Fuel Units at Quad Cities	VIII Delay of Operation of Quad Cities	IX Abandon Quad Cities
River	Temperature and temperature change	Maximum July 85 F Aug. 83 F Sept 80 F River flow 35,000 cfs (exceeded 50 percent of time) 13 200 cfs (7-day 10-year low flow)	Downstream fully mixed temperature increases 1 5 F (35,000 cfs) 4 F (13,200 cfs) ΔT = 23 F across condenser for flow of 2270 cfs	Consumptive use – make upwater – about 70 cfs Mixing device required to reduce blowdown water to river temperature standard	Same as mechanical draft cooling tower	Same as mechanical draft cooling tower Possible infiltration of groundwater system	Approximately the same as the mechanical draft cooling tower Possible infiltration of groundwater system	Same as mechanical draft tower	If present diffuser system were used, same as I If cooling options are implemented, same as II-V	No inputs of waste heat to river over period of delay. Same as present conditions	No inputs of waste heat to river Same as present conditions
Atmosphere	Air quality	Approximately at or below national primary ambient standard levels for SO_2 and suspended particulates Heavy fog 50 hr/yr Moderate fog 61 hr/yr Light fog 150 hr/yr	Same as with present environment	Same ambient air quality as present Fog up to 490 hours per year Light icing on highways Cooling tower plume – up to 12 miles in length, 2 miles wide at 10 miles from plant	Same as present ambient air quality Fog 12 to 30 hours of additional fog per year Cooling tower plume – extend downwind for more than one mile in excess of 30 percent of yearly hours	Same as present ambient air quality Less fog and plumes than mechanical draft towers for wind speeds in excess of 10 mph cannot predict fog potential at low wind speeds	Same as present air quality Fog limited to steam fog above lake	Same as present air quality Same as closed cooling options	140-million pounds of SO_2 emitted per year 23-million pounds of particulates emitted per year Same as nuclear power options	Same as present conditions in Quad Cities area, but see other considerations Same as present conditions	See other considerations
Aquatic	Biota	Fish – an abundant and diverse fish community Sport. Common – white bass, blue gill sauger, channel catfish Limited abundance – smallmouth bass, large-mouth bass, flathead catfish Commercial – buffalo, freshwater drum, carp Benthic organisms – (mainly faculative forms) mayflies caddisflies midgeflies sludgeworms Phytoplankton – relatively stable, diverse population indicative of a somewhat enriched habitat Periphyton	No direct temperature effects expected on fish No adverse effect expected – adjust rapidly to thermal additions outside of direct influence of discharge jet Expect loss of plankton in condenser when ambient temperature is in excess of 74 F no greater than proportional amount of river flow through condenser	Elimination of possible effects of thermal discharges	Elimination of possible effects of thermal discharges	Elimination of possible effects of thermal discharges	Elimination of possible effects of thermal discharges	Elimination of possible effect of thermal discharges	Same as nuclear power options	Same as present conditions in short term	See other considerations

Table 22(1) Summary of Regional Environmental Conditions, Costs and Other Considerations--Continued

Quad Cities Site Specific Environmental Characteristics	Environmental Components and Parameters	Present Quad Cities Environment	Alternatives I Present Plant Design With Jet Diffuser System	II Mechanical Draft Cooling Tower	III Natural Draft Cooling Towers	IV Spray Cooling	V Cooling Lake	VI Mechanical Draft Cooling Towers With Ultimate Radwaste Treatment System[a]	VII Fossil Fuel Units at Quad Cities	VIII Delay of Operation of Quad Cities	IX Abandon Quad Cities
Health and safety	Radioactivity (normal and accidental releases), SO_2 and particulates	Natural radiation background - 140 mrem/yr Man-made radiation background - 100 mrem/yr Cumulative man-rem versus distance from power plant (Normal Background / Man-Rem Background) 10 miles 3,800 2,700 50 miles 90,200 64,400	Cumulative man-rem, Normal Reactor Operation 96 (2.7)[a] 293 (12.7)[a]	Requires additional liquid radwaste treatment facilities to meet US AEC standards in the discharge while providing no significant radiological benefit Highway accidents due to fog and ice 96 (2.7)[a] 288 (8.4)[a]	Requires additional liquid radwaste treatment facilities to meet US AEC standards in the discharge while providing no significant radiological benefit 96 (2.7)[a] 288 (8.4)[a]	Requires additional liquid radwaste treatment facilities to meet US AEC standards in the discharge while providing no significant radiological benefit Highway accidents due to fog and ice 96 (2.7)[a] 288 (8.4)[a]	Requires additional liquid radwaste treatment facilities to meet US AEC standards in the discharge while providing no significant radiological benefit 96 (2.7)[a] 288 (8.4)[a]	Whole-body exposure would be reduced by 8.2 man-rem/yr for a population out to 50 miles through installation of a krypton-removal system, no dilution liquid radwaste system would reduce exposures by 0.2 man-rem/yr to persons drinking only Mississippi River water		No releases in short term over period of delay See other considerations	See other considerations
Esthetics	Quality	Gently sloping terrain to Mississippi River, tree lined banks industrial park complex	Compatible	Mechanical draft towers will not detract from landscape Cooling tower plumes will be recognizable	Natural draft towers will overpower landscape Cooling tower plumes will be recognizable	No effect on existing landscape	Little or no detrimental effect on landscape and might improve beauty of the area	Mechanical draft cooling towers will not detract from landscape Cooling tower plumes will be recognizable		Same as present conditions	Same as present conditions
Other considerations			Construction virtually complete		Natural draft towers are not presently designed to withstand tornadic wind conditions	No experience with systems the size needed	Delay required to acquire 2200 acres for lake	No on-line ultimate radwaste systems for comparison	Delay required for conversion to fossil fired units, power purchases required	Existing system used to produce power augmented by purchases Additional SO_2 and particulates emissions Lack of adequate margins to meet peak loads Restrained economic growth	Inability to meet projected loads No economic growth followed by gradual attrition in environmental quality employment, service, revenues

(a) Ultimate radwaste treatment system includes retention of Kr^{85} and addition of no-dilution liquid radwaste system.

required for placement of the diffuser system. These dredgings have caused some temporary effect on water quality.

The station will use river water for cooling purposes and return it to the river. The present cooling system is designed such that water flowing through the station at a rate of 2,270 cubic feet per second will be heated to 23°F above ambient. After the diffuser-pipe system is installed, it is estimated that the temperature rise within 200 feet will not exceed 5°F under all river flow rates. After construction of the spray-canal, the heat discharged to the river will be about one-twentieth of that discharged before its construction.

The discharge of chemicals, radioactivity, and treated sewage into the river is not expected to have any effects on water quality.

3. Biological Impact

The potential effect of thermal and chemical discharges on the biota in the vicinity of the station is expected to be quite small. However, operational studies are planned to assess any effect. Of most concern is the combination of thermal, chemical, and mechanical effect of organisms entrained in the cooling water.

While it is difficult to assess these effects quantitatively, a gross estimate has been made by the staff. If it is assumed that the adverse effect of entrainment on fisheries is proportional to the ratio of station condenser flow to average river flow (about 5 percent from section III), and the annual fishery (about 100,000 sports fish and about 300,000 pounds of commercial fish from section II), an annual loss of about 5,000 sports fish and 15,000 pounds of commercial fish can be projected. After construction of the spray-canal this loss would be reduced by at least a factor of 20. In order to assure the protection of the aquatic biota during the operation of the diffuser-pipe, the applicants will conduct a monitoring program as delineated in the Technical Specifications.

The heated discharge into the river may attract fish and possibly enhance the fish catch in the vicinity.

4. Radiological Impact

The annual whole-body dose to the population within a 50-mile radius of the station is estimated by the staff to be less than 143 man-rem. After modification of the radwaste system this will be reduced to 49 man-rem. (The applicants' estimates are given in Table 22 as 293 man-rem.) After the applicants have installed additional radwaste equipment, annual average doses to individuals are expected to be an extremely small increment of the doses that the area residents receive from natural background (see table 11).

5. Alternatives to Normal Transportation Procedures

Alternatives, such as providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station, have been examined by the staff for the general case. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

6. Cost-Benefit Balance

In Table 22 is a comparison of environmental effects of various alternatives, taken from the applicants' Supplemental Environmental Report[1] except that figures on capital investment have been removed for separate discussion below. With minor exceptions, this comparison is in agreement with the staff's analysis.

The station as designed, with planned modifications to incorporate a spray-canal to cool the condenser water from both generating units, is expected to have an acceptably small impact on the environment. Other cooling systems would not be environmentally advantageous when the effects on air, land, and water are considered together. The alternative of using fossil fuels to produce the required power would have the environmental disadvantage of contributing substantially to air pollution.

Given below is a tabulation of the incremental costs of various cooling systems relative to the once-through system.

	Incremental Cost in Millions of Dollars			
			Cooling Towers	
	Spray Canal	Cooling Lake	Mechanical Draft	Natural Draft
Initial Investment	30.2 a/	33.0	27.0	39.1
Capability Loss b/	13.2	9.8	9.3	13.2
Operation & Maintenance c/	3.9	1.4	3.6	3.1
Total	47.3	44.2	39.9	55.4

a/ From Supplement No. 5 of April 24, 1972, to the applicants' Environmental Report.

b/ Due to additional pumping requirements and loss of efficiency resulting from increased back-pressures on the turbine.

c/ Equivalent investment for which annual fixed charges would equal annual costs of fuel, maintenance, and loss of efficiency.

Although their costs are given as less than for a spray-canal, the cooling lake has the disadvantage of requiring the purchase of about 2200 additional acres of farmland and the mechanical-draft cooling towers have the disadvantages of increased noise levels at the plant site and increased ground fogging away from the site.

The alternative of not operating the nuclear plant at Quad-Cities and converting it to a plant burning coal or oil would require an additional capital investment estimated at almost $300 million; the purchase of replacement power, if available, at a cost of $300 to $500 million during the five-year construction period for the fossil-fuel plant; and annual fuel costs several times greater than for the nuclear plant. The principal environmental result would be air pollution from emissions of large quantities of sulfur dioxide, nitrogen oxides, and particulates, even if the standards for such emissions were met.

A summary of the benefits and environmental costs of operating the Quad-Cities plant as presently planned is given in Table 23. The primary benefits are providing needed electrical energy to meet the demand on the applicants' power system and adding to the reliability of power supply for other interconnected utilities. A secondary benefit is stimulation of the local economy through direct employment of the

Table 23
Benefit-Cost Summary of Quad-Cities Units 1 and 2

Benefits	
Primary benefits:	
Electric energy to be supplied	About 10 billion kilowatt hours/yr.
Electric capacity contributing to reliability of power supply of Mid-American Interpool Network	1.6 million kilowatts
Secondary local benefits:	
Employment of operating staff	180 persons receiving total payroll of $2,500,000 per year
Property taxes paid by the plant	$900,000 per year
Environmental Costs	
Impact on land use:	
Farmland for station	560 acres
Farmland in right-of-way for transmission lines*	1400 acres
Fogging and icing	Some increase in natural fogging near spray canal and possibility of increase in light fog across Illinois Route 84; possibility of icing near spray-canal on coldest winter days.
Impact on aquatic life:	
Intake from Mississippi River	
a. Before operation of spray-canal	About 5% of average annual river flow resulting in some entrainment and mortality of aquatic life
b. After operation of spray-canal	Less than 1/4% of average annual river flow, with negligible impact on aquatic life

*Most of this land is still available for farming.

Table 23 (cont'd)

Discharge to Mississippi River	
a. Before operation of spray canal	2270 cfs of heated water, with possibility of appreciable impact on aquatic life
b. After operation of spray canal	50 cfs of heated water (125 cfs on occasion for short periods), with negligible impact on aquatic life
Radiological impact:	
Routine operation	
Cumulative dose from operation of Units 1 and 2	143 (49)* man-rem per year or about 0.24% (0.08%)* of natural background
Whole body dose from noble gases to individual at site boundary	70 (4.4)* man-rem per year or about 70% (4.4%)* of natural background
Accidents during operation or transportation	Annual potential radiation exposure of population from all postulated accidents is small fraction of natural background.

* Numbers in parenthesis indicate values after modified radwaste system is installed.

operating staff and through taxes paid during plant operation. In addition, the plant will contribute to the regional economy by making energy available for new industrial, commercial, and residential uses. The environmental costs are minor and include a temporary impact on a portion of the local aquatic life in the Mississippi River until the spray canal goes into operation, drift and the possibility of some increase in fogging and icing on the site when the spray-canal is in operation, and radiological doses to the population that are a small fraction of natural background, either during normal operation or for postulated accidents.

In conclusion, the staff has analyzed the known identifiable and potential benefits and costs and finds that, on balance, the benefits exceed the costs.