Final

environmental statement

related to operation of

PALISADES NUCLEAR GENERATING PLANT

CONSUMERS POWER COMPANY

DOCKET No. 50-255

June 1972

RETURN TO REGULATORY CENTRAL FILES
ROOM 016

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. The action is the issuance of an operating license to the Consumers Power Company for the full power operation of the Palisades Nuclear Generating Plant, (Docket No. 50-255), a nuclear power reactor located in the State of Michigan, Van Buren County, Covert Township, near the City of South Haven, along the eastern shores of Lake Michigan. On November 20, 1971, the applicant was granted Amendment No. 1 to the Interim Provisional License No. DPR-20 to operate the Palisades Plant at a steady state power level of 20% of the rated power level of 2,200 megawatts thermal (MWt). On March 10, 1972, the applicant was granted Amendment No. 2 to DPR-20 to operate the Palisades Plant at 60% of the rated power level.

   The Palisades Plant uses a pressurized water reactor to produce up to an initial power rating of 2,200 megawatts thermal (MWt). A steam-turbine generator will use this heat to provide an output of 715 megawatts electrical (MWe) of which 15 MWe is used in-plant. Initially the exhaust steam will be cooled by once-through flow of water obtained from and discharged into Lake Michigan. After January 1, 1974, mechanical-draft cooling towers will be used.

3. Summary of environmental impact including beneficial and adverse effects follows:

   a. The major benefits of this project will be the annual production of 5.2 billion kilowatt hours (kW hr), which will serve to increase the reliability of the electrical energy system during periods of peak load demand. Other benefits include an addition of 360 feet of lake front property to the Van Buren State Park in exchange of land with the applicant and the educational benefits from the visitors' center.

   b. About 487 acres of land formerly used as a quarry, bordering about 1 mile of the eastern shoreline of Lake Michigan, have been converted to industrial use; of the total area, about 90% remains as windrows of sand dunes, covered with dune grasses and partly forested. Land disturbed during construction has been landscaped with vegetation native to the area.

c. The construction of two 345-kilovolt transmission lines, one of which involved a 1/2-mile clearance of a 150-foot wide corridor (about 5 acres) over the sand dunes and the second of which involved a 40-mile long corridor of varying widths (about 2,250 acres), has been required to connect the Plant to the power distribution system of the applicant and its partner in the Michigan Power Pool. Farming will be permitted up to and between transmission line structures where right-of-ways cross agricultural land.

d. The impact of the routine releases of radioactive materials will be negligible. The estimated dose from operation of the Plant to the population living within 50 miles is 0.57 man-rem per year. A very low probability risk of accidental exposure to radiation will be created.

e. A modified radwaste system to be in use by Spring of 1973 which will include evaporators and demineralizers will recycle wastes (with the exception of laundry wastes) to serve to reduce liquid radwastes to levels comparable to the guidelines of proposed Appendix I to 10 CFR 50. Gaseous radwastes will be held up for 60 days rather than 30 days to permit a greater decay of short-lived radioactivity.

f. The present once-through condenser cooling system raises 405,000 gallons per minute (gpm) of Lake Michigan water to 25F° above ambient resulting in a thermal plume with an area of 370 acres within the 3F° excess temperature isotherm. This area represents only 0.002% of the total area of Lake Michigan. Although these thermal discharges will meet the standards set for this Plant by the State of Michigan Water Resources Commission, they will not meet the Environmental Protection Agency's recommendations for thermal discharges for Lake Michigan after December 31, 1973.

g. Although thermal discharges may have localized effects such as interruption of passage of juvenile fish along the shoreline and thermal shock on spawning of certain fish, free-swimming biota are not expected to remain in the mixing zone for sufficiently long time to be adversely affected. The dominant effect will be the attraction of fish to the warm water area of the plume, especially during the winter months.

h. For the most part fish and free-swimming organisms may avoid impingement or entrainment in the once-through cooling system because of the location of the intake crib, which is 20 feet below the lake surface, 6 feet from the bottom, and 3,300 feet from the shoreline, and the low intake velocity of 0.5 to 0.6 feet per second. Since zooplankton recover and reproduce rapidly, the 30% entrained and killed in the cooling water will have a minimal effect on the productivity of the lake as those killed will serve as a food base for other biota in the lake.

i. The limited chlorine treatment of 1 hour per month at concentration levels of 0.5 ppm residual chlorine will reduce to a minimal level the chlorine impact on aquatic life in the vicinity of the Plant.

j. Although operation of the Plant with the once-through cooling will cause an adverse effect on a small fraction of the nearby aquatic community, the impact is considered to be of little significance on the overall population levels of biota in Lake Michigan.

k. After January 1, 1974, the applicant is committed, through an agreement with the intervenors in the licensing proceeding, to have installed and commence operation of mechanical-draft cooling towers to reduce the thermal load rejected to the lake. The use of the towers reduces impingement, entrainment and thermal impact on fish and other aquatic biota. However, they introduce a long-term adverse impact of chemicals from continuous blowdown of 1,320 gpm of concentrated salts which would accumulate in Lake Michigan over the long-term operation of the cooling towers and cause serious degradation of the water quality of Lake Michigan in the vicinity of the Plant. The increased concentration would result in phosphate enrichment of the lake water and reconcentration of zinc and chromate in biota.

l. Cooling towers introduce terrestrial environmental impacts on flora and fauna in the dunes from chemicals deposited by the drift, evaporation of 12,320 gpm of lake water, fogging under certain meteorological conditions, and icing in the winter. Although the towers are hidden from view, they will cause an adverse aesthetic effect from the lake side and will have a noise impact on the area.

m. The cooling towers will not only require an increase in capital and operating costs of the order of about $67,000,000 but will result in a decrease of about 3% in net electrical output due to the electrical power required for the fans in the towers.

4. Alternatives considered were:

   a. Use of fossil fuels

   b. Heat dissipation with mechanical draft cooling towers

   c. Heat dissipation with natural-draft cooling towers and dry cooling towers

   d. Heat dissipation with cooling ponds and spray ponds

   e. Reduction of thermal effects with a redesigned and relocated discharge structure

   f. Reduction of chemical effects with a redesigned condenser cleaning system

   g. Use of a modified radwaste system.

5. The Federal, State, and local agencies listed below and the applicant have commented on the Draft Environmental Statement and their comments have been considered in the preparation of the Final Environmental Statement.

   Advisory Council on Historic Preservation
   Department of Agriculture
   Department of the Army, Corps of Engineers
   Department of Commerce
   Environmental Protection Agency
   Federal Power Commission
   Department of Health, Education and Welfare
   Department of the Interior
   Department of Transportation
   State of Michigan Department of Natural Resources
   State of Michigan Department of Public Health
   Covert Township Supervisor

6. This Final Environmental Statement is being made available to the public, to the Council on Environmental Quality, and to other agencies in June 1972.

7. On balance, the staff concludes that the minimal ecological impact foreseen by operation of the Palisades Plant with once-through cooling does not provide sufficient justification for the additional increased cost to the consumer necessary to provide cooling towers inasmuch as the ecological impact of the cooling towers is minimal and comparable to that of once-through cooling. Thus, on

the basis of the analysis and evaluation set forth in this Statement, after weighing the environmental, economic, technical and other benefits of the Plant against environmental costs and considering available alternatives, it is concluded that the action called for would be the issuance of an operating license authorizing operation of the facility with an once-through cooling system.

The project before the Commission for licensing consideration, however, is one in which mechanical draft cooling towers are to be installed for operation by January 1, 1974. Since the ecological impact of the operation of the Plant utilizing the cooling towers as proposed by the applicant is comparable to that associated with operation utilizing once through cooling, the use of such towers is an acceptable action in terms of its environmental effects. Accordingly, weighing the environmental, economic, technical and other benefits of the Palisades Plant utilizing mechanical-draft cooling towers against environmental costs thereof and finding no alternatives (other than those specified as conditions below) which would materially reduce environmental damage or enhance the benefits compared to the environmental costs, the staff concludes that (despite the lower cost of the alternative of once-through cooling) the action called for is the issuance of an operating license, authorizing operation of the Plant with once through cooling prior to January 1, 1974 and with mechanical draft-cooling towers thereafter, subject to the following conditions for protection of the environment:

a. For the period prior to operation with cooling towers, the following conditions apply for protection of the environment:

    (1) The incorporation of a non-radiological, as well as radiological, monitoring program as required in Appendix B to Amendment No. 2, for the Technical Specifications to License No. DPR-20.

    (2) The performance of a monitoring program to determine:

        (a) chlorine discharges and its effects on biota;

        (b) size, shape and location of different isotherms of the thermal plume during different wind and weather conditions;

(c) thermal discharges and their effects on spawning fish eggs and larvae and interruption of migratory paths of fish along the shoreline corridor;

(d) impingement and its effects by counting the number, types, and sizes of fish collected on the screens and trash racks of the intake structure, and entrainment by measuring the extent of mortality and damage of biota, such as plankton, after passage through the condenser;

(e) any changes in biota life in bottom areas of the lake, around the intake crib and the discharge canal, and on the beach from the operation of the Plant with the once-through cooling system.

(3) Concurrent development of an affirmative plan of action for Plant operation to prevent and remedy detrimental effects on biota, to include means of reducing cold kills, chlorine discharges, and to improve dispersion of the thermal plume through an alternate discharge structure design. Such a plan shall provide for implementation so as to eliminate or significantly reduce such effects as are revealed by the monitoring program.

b. For the period that cooling towers are used, the conditions specified under a., above, plus the following:

(1) Extension of Technical Specifications to include monitoring of effects of operation with the cooling towers on terrestrial biota, including salt deposition from drift and extent of fogging and icing, and on aquatic biota from the continuous discharge of chemicals in the cooling tower blowdown in the lake.

(2) The development and use of alternate methods to effectively reduce or eliminate the amount and type of toxic chemicals as corrosion inhibitors and biocides in the operation of the cooling towers or by treatment of such chemicals to minimize the impact.

(3) An evaluation of comparative effects of the two alternate cooling systems on the environment.

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FOREWORD

This Final Detailed Statement on Environmental Considerations (the Statement) related to the proposed issuance of an operating license to the Consumers Power Company, (the applicant), for its Palisades Nuclear Generating Plant (Docket No. 50-255), has been prepared by the U. S. Atomic Energy Commission's (the Commission) Regulatory Staff (the staff) in accordance with the Commission's regulation, Title 10, Code of Federal Regulations, Part 50 (10 CFR 50), Appendix D as revised on September 9, 1971 (36 FR 18071), and further revised on September 30, 1971, November 11, 1971 and January 20, 1972, and corrected on September 21, and December 16, 1971, implementing the National Environmental Policy Act of 1969. (P.L. 91-190, 83 Stat. 852).

Section 102(2) of the National Environmental Policy Act calls for all agencies of the Federal Government to utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment; to identify and develop methods and procedures which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations; and to include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

In addition, Section 102(2) of NEPA requires the Commission to study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources; and to recognize the world-wide and long-range character of environmental problems.

The application of the applicant for a license to operate the Palisades Plant is presently pending before the Atomic Safety and Licensing Board (the Board) pursuant to a Notice of Hearing in this proceeding published in the Federal Register on March 10, 1970 (35 F.R. 4310). On that date the Commission published a Notice of Proposed Issuance of Provisional Operating License No. DPR-20 for the Plant, which stated that the applicant's application for an operating license complied with the Atomic Energy Act of 1954 and the pertinent regulations and that it was the intention of the Commission to issue such a license.

Petitions to intervene in the licensing proceedings were filed by several citizens organizations. On May 18, 1970, the Commission granted leave to intervene to the Michigan Steelhead and Salmon Fisherman's Association, Thermal Ecology Must be Preserved (TEMP), Concerned Petitioning Citizens, and the Michigan Lakes and Streams Association; at a later date the Commission extended leave to intervene also to the Sierra Club. In subsequent discussions between these intervenors and the applicant, the applicant agreed to employ wet-type cooling towers rather than the once-through cooling system and to modify the liquid radioactive waste discharges into Lake Michigan. This settlement agreement was executed on March 12, 1971. The Commission was not a signatory to the agreement between the applicant and the intervenors. Description of the modifications is given in Amendment No. 21 to the application, dated March 1, 1971. Amendment No. 24, dated June 17, 1971, and called "Special Technical Specifications Pursuant to Agreement," spells out the details on limiting the radioactive releases from the liquid radwaste system and on modifications of the condenser cooling system and on limiting thermal discharges from the cooling tower system.

In accordance with NEPA and Appendix D of 10 CFR 50 of June 3, 1970 (35 F.R. 8594), the staff transmitted on October 16, 1970 copies of the applicant's Environmental Report of October 9, 1970, and the updated operating license application for the Palisades Plant to appropriate Federal and State agencies for review and comment. The applicant responded to the comments of the agencies. The Commission incorporated these comments in the Final Detailed Statement issued on April 7, 1971, which superseded the Commission's

Statement on Environmental Considerations for the Palisades Plant that had been forwarded to the Council on Environmental Quality on June 8, 1970. The Draft Detailed Statement of February 29, 1972 and this Final Statement supersede the April 7, 1971 Statement.

The applicant submitted "Supplemental Information on Environmental Impact of Palisades Plant" on August 18, 1971. In compliance with the revised Appendix D to 10 CFR 50 of September 9, 1971, the applicant submitted "Supplemental Information on Environmental Impact of the Palisades Plant - November 3, 1971." On November 11, 1971, the applicant forwarded "Request for Additional Information on Environmental Considerations, Palisades Plant, Docket No. 50-255;" on December 29, 1971, "Additional Information on Environmental Considerations - Palisades Plant;" and on February 8, 1972, information on the capital and operating costs for the condenser cooling system and liquid radwaste system modifications. The applicant also responded on May 3, May 12, and May 19, 1972 to the Federal and State comments on the Draft Detailed Environmental Statement.

This Final Statement is based primarily on the applicant's Environmental Report and Supplements thereto, Final Safety Analysis Report and amendments thereto, the Commission's Safety Evaluation and Supplements, as well as on the referenced documents listed at the end of each chapter. Comments received from Federal, State, and local agencies on the Draft Detailed Environmental Statement of February 29, 1972 have also been taken into account in the preparation of this Final Statement.

Independent calculations and public sources of information cited in the references at the end of each chapter were utilized as a basis for the Commission's assessment of environmental impact. In addition, information concerning the Palisades Plant, the site, and its environs were directly obtained by the Commission's representatives responsible for this assessment during a visit to the Palisades Plant and neighboring communities.

The revised Appendix D also provides for a procedure (subsection D.2) for issuance of a license authorizing the loading of fuel in the reactor core and limited operation within the scope of 10 CFR 50.57(c), where the requirements of paragraph 1-9 of section A of Appendix D have not as yet been met. As such, on September 27, 1971, the applicant filed a motion requesting the Board to authorize the Director of Regulation to issue an amendment to the Interim Provisional Operating License DPR-20 authorizing operation of the Palisades Plant at power levels not to exceed 1,320 thermal megawatts (MWt) (60% of the facility's rated power level of 2,200 MWt). As a result of public hearings before the Board on October 26, 1971 and on January 25-26, 1972 and upon approval of the Commission to operate at power levels greater than 20% of rated power, Amendment Nos. 1 and 2 to DPR-20 were granted to the applicant on November 20, 1971 and on March 10, 1972 by the Director of Regulation to authorize operation at 20% and 60% of rated power, respectively.

All material submitted by the applicant in support of its application, its Environmental Report and Supplements, and other pertinent documents are available for public inspection at the Commission's Public Document Room at 1717 H Street, N.W., Washington, D.C., 20545; at the Office of the Supervisor of Covert Township, Covert, Michigan; at the Office of the Chairman of the Board of Supervisors, Van Buren County, Michigan; and in Suite 201, Kalamazoo City Hall, 241 West South Street, Kalamazoo, Michigan. Copies of these documents have also been forwarded to appropriate Federal agencies, State of Michigan, and local officials.

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.

I. INTRODUCTION

A. GENERAL

The Palisades Nuclear Generating Plant, (Palisades Plant) (Docket No. 50-255), owned and operated by the Consumers Power Company, of Michigan (the applicant) is located on a 487-acre site on the eastern shore of Lake Michigan in a semi-rural area in Covert Township, Van Buren County, Michigan. The site is approximately 4-1/2 miles south of the southern city limits of South Haven and about 16 miles north of Benton Harbor and St. Joseph. The site is bordered by U. S. Highway 31 and Interstate Highway I-196 to the east, by a 310-acre Van Buren State Park immediately north of the site, and by the Covert Township Park and private residences south of the site.[1]

The site itself was a former quarry and is surrounded by sand dunes which rise from the beach level, surround the site on three sides, and are partly wooded and covered with dune grass. The site is bounded on the west by Lake Michigan with nearly 1 mile of lake frontage. The land inland from the site is slightly rolling and partly wooded with many open fields, berry farms, and orchards. The area surrounding the site is used for farming and recreational activities and is sparsely populated. During the summer months the population along the lake increases.

The Palisades Plant, in which construction has been completed since about Spring 1971, will generate initially 700 megawatts of electricity (MWe) with a capacity to increase its electrical output up to 821 MWe. The electricity generated will be distributed to the applicant's system and that of the Michigan Power Pool, of which the applicant and Detroit Edison Company are the principal partners. The Plant will utilize a pressurized-water nuclear reactor system in which the exhausted steam produced will initially be condensed by means of a once-through condenser-cooling system using Lake Michigan water to dissipate the waste heat. The waste heat will increase the cooling water temperature 25 F° above the ambient at the intake during operation at 700 MWe. The temperature increase is at the outfall where the discharged water enters into Lake Michigan. The total flow rate through the once-through cooling system is about 405,000 gallons per minute (gpm). The applicant is committed by an agreement with the intervenors to install wet-type cooling towers to reduce the thermal load to Lake Michigan.

The Statement to follow describes the present facility, its site and environs, the assessment of the potential impact of the construction and normal and abnormal operation of the Palisades Plant on the environment. Discussion of need for power, alternative facility design and operation with a benefit-cost analysis is also presented for the purpose of evaluating methods for minimizing any adverse environmental impact of the design and operation of the Palisades Plant. Federal, State and local agencies' comments have been taken into account in the body of the text under the appropriate subject and are presented in Chapter XII of this Statement.

B. SITE AND FUEL SELECTION

The selection of a site for construction of an electricity-generating facility depends on many factors. The generating capacity of the power plant is a primary factor. Large generating units (which are more economical than smaller units) place restrictive requirements on prospective plant sites. Power plants using fossil fuel (coal or fuel oil) must have available the means, such as railroads or navigable waters, of transporting bulk materials in large quantities. In addition, each fossil- or nuclear-fueled power plant requires a large volume of water for dissipating the waste heat inherent in the steam-electric cycle.

Another consideration in the selection of plant sites is the distance to the load centers, since transmission losses increase with distance. Nearness to existing transmission facilities decreases the capital investment required to place new power generation on line.

Public acceptance of a plant site is also desirable. Public pressure to preserve scenic natural features, or to prevent the placement of a power plant near residential areas of high population density, influences the ultimate selection of a power plant site.

In 1965, the applicant began the selection of a site for a proposed 700 MWe generating plant. On the basis of a joint study by the applicant and Detroit Edison Company for the Michigan Power Pool in early 1965, the decision was made for the applicant to build the next major generating unit to meet increasing Pool demands.[2] Among the possible sites considered for this new power plant were the existing sites occupied by the Whiting IV, Karn, and Campbell III plants. Other potential sites were the Palisades and the Quanicassee properties. The Palisades site was selected for nuclear generation over Campbell III, Quanicassee I and Whiting IV and Whiting IV was chosen for a coal-fired unit. The potential plant sites and the type of plant are shown in Fig. I-1, along with the operating plants in the Michigan Power Pool. All sites are adjacent to significant bodies of water: Whiting along Lake Erie, Karn and Quanicassee along Lake Huron, and Campbell and Palisades along Lake Michigan. Therefore, cooling water was available in sufficient quantity at each site. In addition, the adjacent bodies of navigable water permit the delivery of bulk fuel, especially oil which might be purchased from overseas sources. The existing sites had railroad facilities already installed, and the other sites had railroad facilities nearby. The Palisades site is also located near major highways.

Each of the sites is observed to be within reasonable transmission distance of the load centers, which are concentrated in the southern portion of lower Michigan, i.e., below the dashed line on the map. Transmission losses are not severe in any case.

After the site selection had been narrowed to Whiting for a coal-fired plant and Palisades for a nuclear plant, the applicant stated that the selection of Palisades was influenced by the best solution to the transmission requirements. The applicant and Detroit Edison Company had begun construction of a 345-kilovolt transmission line across Michigan to provide more efficient interchange of power.[3,4] Therefore, a plant at the Palisades site could be connected onto an existing, primary distribution line at minimal cost. In addition, the energy generated at this site would be available with only small distribution losses to the Kalamazoo and Battle Creek load centers. Since then a 345-kilovolt interconnection to the Indiana and Michigan Electric Company has been completed, so the Palisades Plant output can be fed to the industrial load centers of northern Indiana. The Donald C. Cook Nuclear Plant (2,200 MWe) (which is under construction about 30 miles south of the Palisades site), also shown in Fig. I-1, can provide power to the Michigan Power Pool if needed by means of this interconnection.

In 1969, the "Generation Study" of 1965, was reevaluated for 1970 power requirements by the applicant using up-to-date costs and other revised data. From both studies, it was concluded that construction of a nuclear plant at Palisades was the optimum choice.[2]

Although originally selected on the basis of economic considerations, the Plant site as a sand quarry was a good choice, particularly for use as a nuclear plant, since it was in a low population area and would not displace any year-round

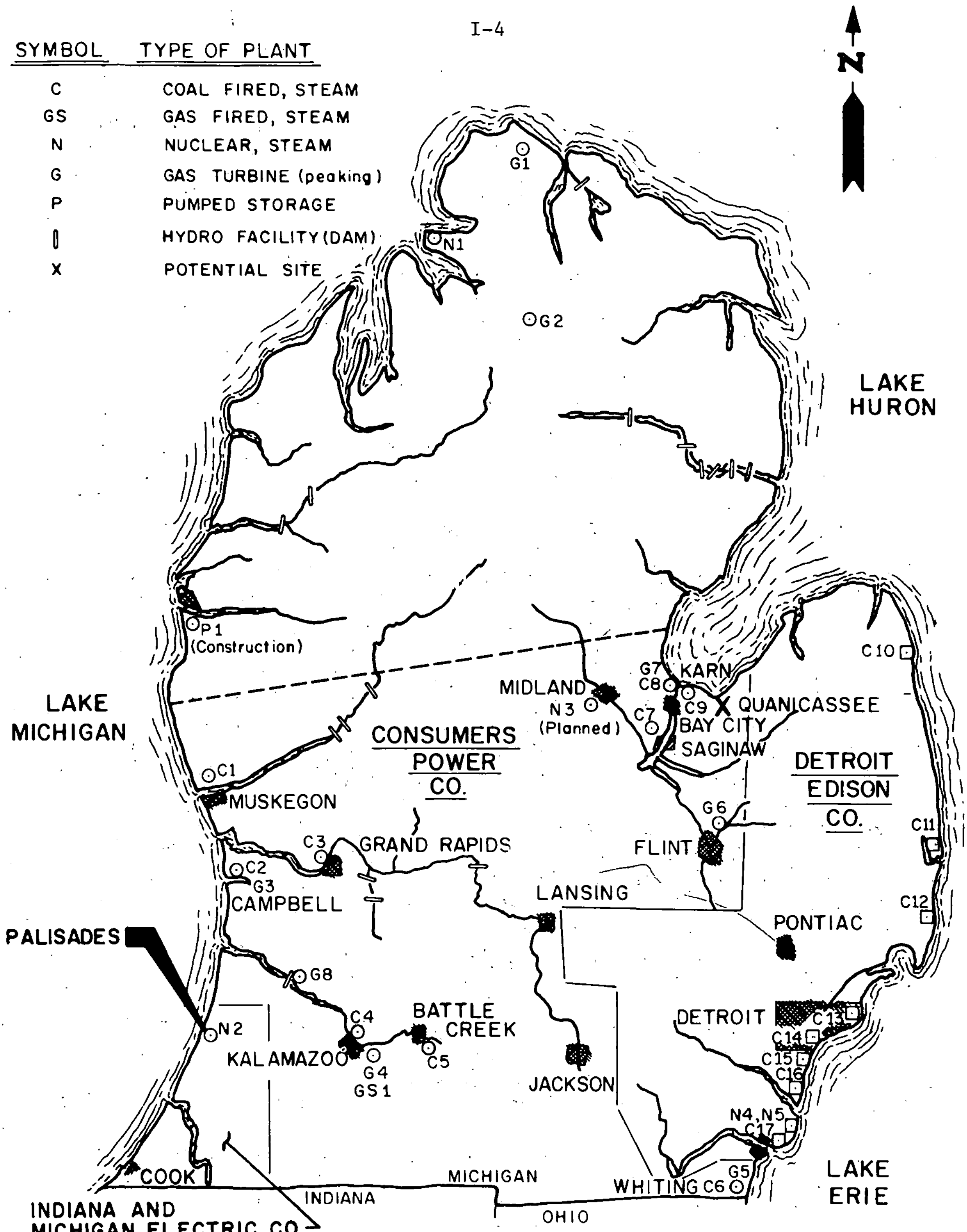


Fig. I-1

LOCATION OF POWER PLANTS AND PLANT SITES IN MICHIGAN POWER POOL homes, only several summer cottages. From an environmental point of view, the replacing of the sand quarry operation with an attractive Plant on a plot of land landscaped with dune grasses, pine trees, and other indigenous and native plant material has been most favorable to the appearance of the total area. Details of the landscaping of the site carried out by the applicant to stabilize the dunes are presented in Chapter IV.

C. APPLICATIONS AND APPROVALS

Table I-5 lists the applications filed by the applicant and the approvals received from various governing bodies or agencies.[1,2] For those applications which have been granted, the date of issuance is included.

TABLE I-1

Federal, State and Local Authorizations Required for Construction and Operation of the Palisades Plant

Agency	Date of Issuance	Permit, License, Etc.
Federal		
Atomic Energy Commission	3/15/67	Plant Construction Permit
	3/24/71	Low Power (1MWt) Operating License
Army Corps of Engineers	5/23/66	Permit to deposit sand in Lake Michigan
	9/12/66	Permit to rehabilitate 4,200 feet of beach by spreading sand
	3/31/67	Section 10 Permit to construct intake line and discharge channel in Lake Michigan
	5/15/68	Permit to construct a temporary barge slip in Lake Michigan and dredge approach thereto
	5/7/69	Permit to dredge to the approach to an onshore discharge structure in Lake Michigan.
	Application dated 6/23/71 (revised 10/15/71)	Section 13 Permit for discharge into Lake Michigan under the Refuse Act of 1899 and being reviewed by Environmental Protection Agency.
Department of Transportation - Federal Aviation Administration	Application dated 5/4/71	Nonobjection received for construction of steel tower transmission line (Palisades-Tallmadge)

Agency	Date of Issuance	Permit, License, Etc.
State of Michigan		
Department of Aeronautics	Application dated 5/4/71	Nonobjection received for construction of steel tower transmission line (Palisades-Tallmadge)
Department of Commerce - Public Service Commission	8/24/66	Orders to permit construction of railroad spur across highways
Department of Labor	4/18/68 2/25/69 1/1/71	Boiler installation permits
Department of Natural Resources (formerly Department of Conservation)	1/17/68	Easement to construct and maintain water intake line and discharge conduit
Department of Natural Resources (formerly Department of Conservation)	4/15/68	Permit to excavate, alter or modify Great Lakes bottomlands for temporary barge slip and for intake structure and discharge channel
	9/14/66	Permit to spread surplus sand from site grading on state-owned lake bottomlands
Water Resources Commission	10/27/66	Order of Determination No. 931 covering new use of state waters
	11/19/71	Amendment Order No. 1582 covering thermal discharges with the size of mixing zone for a 3°F isotherm and chlorine discharges
Department of Public Health	10/3/66	Approval of sanitary sewage system
		Construction and operating permits for air pollution control equipment (application pending)

Agency	Date of Issuance	Permit, License, Etc.
Van Buren County		
Board of Commissioners (formerly Board of Supervisors	5/20/69	Resolution to abandon portion of Blue Star Highway
Board of County Road Commissioners	6/8/67	Easement for railroad spur across highways
	11/14/66	Agreement for relocation of Blue Star Highway
Covert Township		
Building Inspector	Plant - 3/22/66 Sub-3/2/66 (Incl W/Plant) Info Center - 10/14/69	Building permits for Plant, substation and Information Center
Township Board	11/7/66	Permit to use township highways, streets, alleys, etc., for electric transmission line facilities

REFERENCES FOR CHAPTER I

1. Consumers Power Company, "Environmental Report Operating License Stage for Palisades Plant," U. S. Atomic Energy Commission, Docket No. 50-255, October 9, 1970.

2. Consumers Power Company, "Requests for Additional Information on Environmental Considerations, Palisades Plant-Docket 50-255", enclosed in a letter from R. C. Youngdahl, Senior Vice President of Consumers Power Company, to R. C. DeYoung, Division of Reactor Licensing, U. S. Atomic Energy Commission, dated November 11, 1971, pp. 8 to 11.

3. Consumers Power Company Annual Report, 1970, Jackson, Michigan.

4. Detroit Edison Company Annual Report, 1970, Detroit, Michigan.

II. THE SITE

A. GENERAL

The Palisades Plant is located on the eastern shore of Lake Michigan in a semi-rural area of Michigan (Fig. II-1). The land within the site boundary, all owned by the applicant, consists of 487 acres of sand dunes, with about 1 mile of lake frontage (Fig. II-2.) The minimum exclusion radius is about 2,300 feet and the minimum distance from the facility to the site boundary (excluding the boundary on the lake front) is 2,200 feet. The low population zone, which is bounded by a 3-mile radius all around the location of the Plant, incorporates the Palisades Plant site, the Van Buren State Park, the Covert Township Park, and privately owned land. (The terms "exclusion area" and "low population zone" are defined in the Commission's regulations in 10 CFR 100.) The closest city of any sizeable population is South Haven, which is about 5 miles north of the site.

Previously, the site area had been used as a sand quarry and had not been reclaimed prior to construction of the Plant. The site is bounded on the west by the lake and on the remaining three sides by wooded sand dunes which range from 610 to 740 feet above sea level near the shore and then drop off abruptly to 610 feet approximately 2,400 feet inland. The area surrounding the site is used for farming and recreational activities and is sparsely populated. Meteorology and hydrology of this site are favorable for good dispersion and dilution of Plant effluents through the atmosphere and water.

In this section are presented facts and figures related to the demographic, economic, historic, physical, and ecological characteristics of the geographic area chosen for the location of the Palisades Plant. This information is used in later sections of this Final Statement to evaluate the interaction of the Plant with its environs.

B. LOCATION OF PLANT

The site is approximately 35 miles north of the Michigan-Indiana border in Covert Township, Van Buren County, Michigan. The 487-acre site is approximately square and is bordered by the 310-acre Van Buren State Park on the north, U. S. Highway 31 and Interstate I-196 on the east, and Covert Township Park and private property on the south. These parks presently make up the total public recreational facilities of Van Buren County.[1] Figure II-2 shows the plot plan and topography of the site.

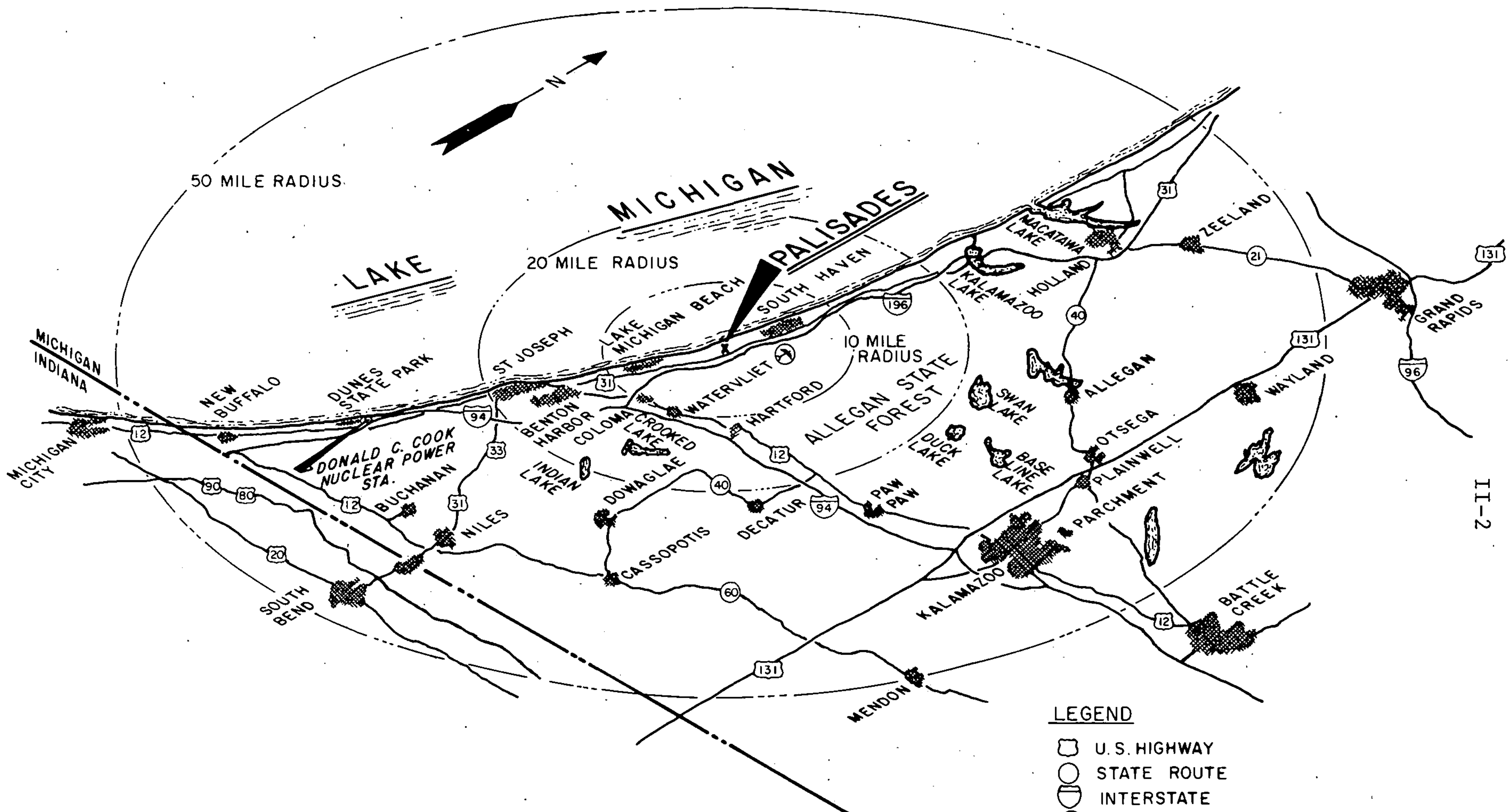


Fig. II-1

ENVIRONS OF THE PALISADES PLANT SITE

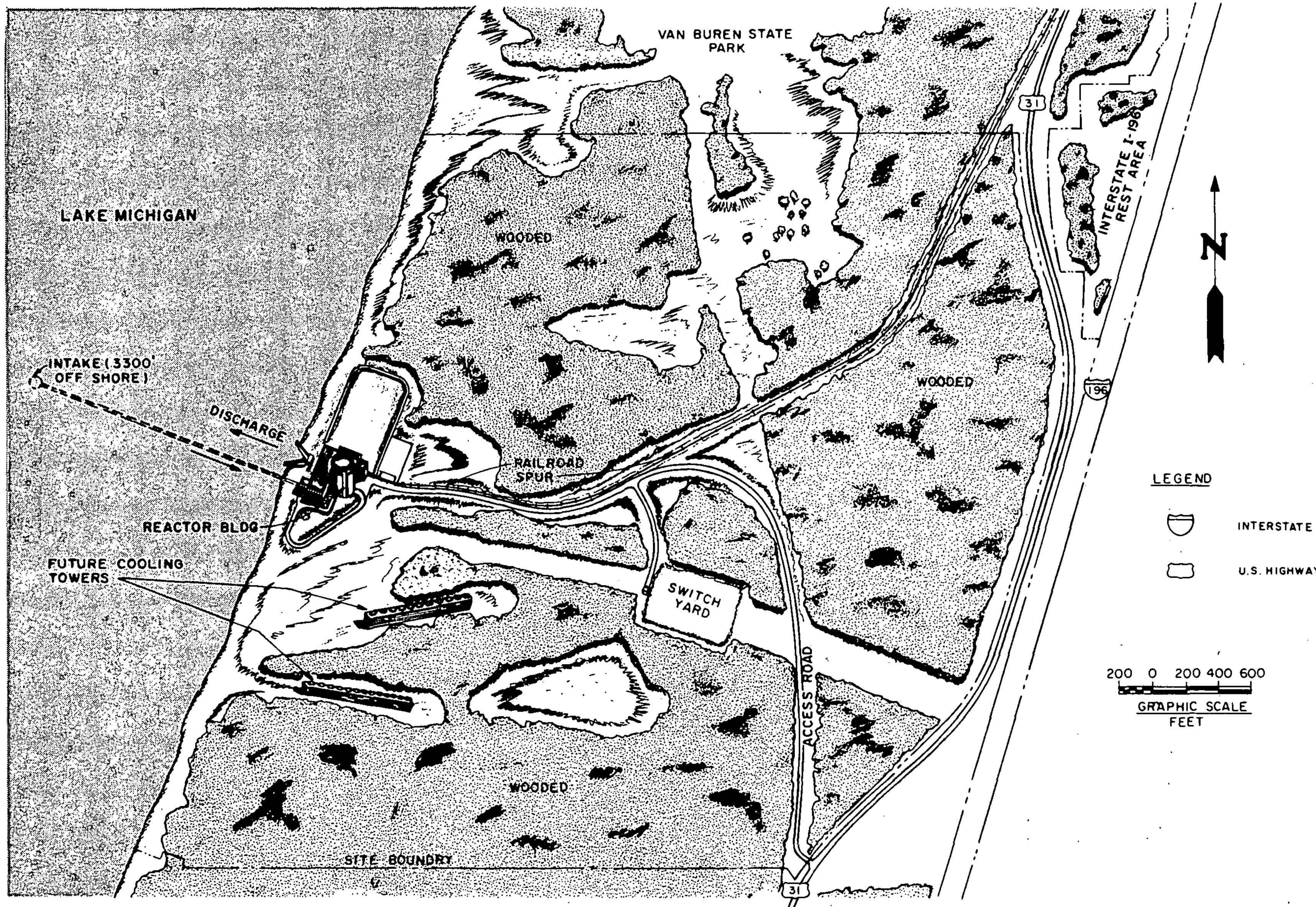


Fig. II-2

SITE

PALISADES PLANT

Before construction was initiated, land was exchanged between the State of Michigan and the applicant to provide increased beach facilities for Van Buren State Park and additional inland space for the applicant. A section of Highway 31 was relocated eastward so as to be outside both the Plant site and the State Park. Access to the site is now afforded by means of a new road that connects with Highway 31 and by means of a railroad spur to the Chesapeake and Ohio Railroad northeast of the site. Boundaries of the site are posted, and entrance to the immediate Plant area is controlled by a security fence. Activities on the site will be limited to the generation of power. A visitor's center is located outside the fenced area.

To the east of the highways the land is partially wooded, with many open fields, berry farms, and orchards. This area is drained by Brandywine Creek, which subsequently flows into Lake Michigan through a gap in the dunes approximately 3,000 feet south of the Plant site. There is one water well on the site. The nearest domestic wells are located 1/2 mile to the east and south of the site. Present data indicate that the free groundwater in the vicinity of the easterly wells is flowing toward the site. Local groundwater in the area of the southerly wells is flowing toward the lake and perpendicular to the shoreline. It is difficult to envision a condition which would cause sufficient groundwater lowering at any of the domestic wells such that the direction of flow might be reversed. The nearest municipal water supply that draws water from Lake Michigan is located at South Haven, 5 miles north of the site.

C. REGIONAL DEMOGRAPHY AND LAND USE

The area within a 50-mile radius of the Palisades site encompasses portions of nine counties in Michigan and three counties in Indiana, which have total populations based on the 1970 census of 1,156,268 and 476,916, respectively.[2] Five of the more distant counties (LaPorte, St. Joseph, and Elkhart in Indiana and Kalamazoo and Kent in Michigan) are more than 60% urbanized and contain the industrial cities of South Bend, Mishawaka and Elkhart, Indiana, and Kalamazoo and Grand Rapids, Michigan. The remaining seven Michigan counties are 52% to 83% rural and the land is devoted principally to fruit orchards, berry farms, fields of corn and barley, and the raising of poultry and hogs. The urban population of this section is shown in Fig. II-3.

Van Buren County (population 56,173) is the next to the least urbanized of all of these counties (22%); the largest incorporated city is South Haven (population 6,471). Based on the current growth

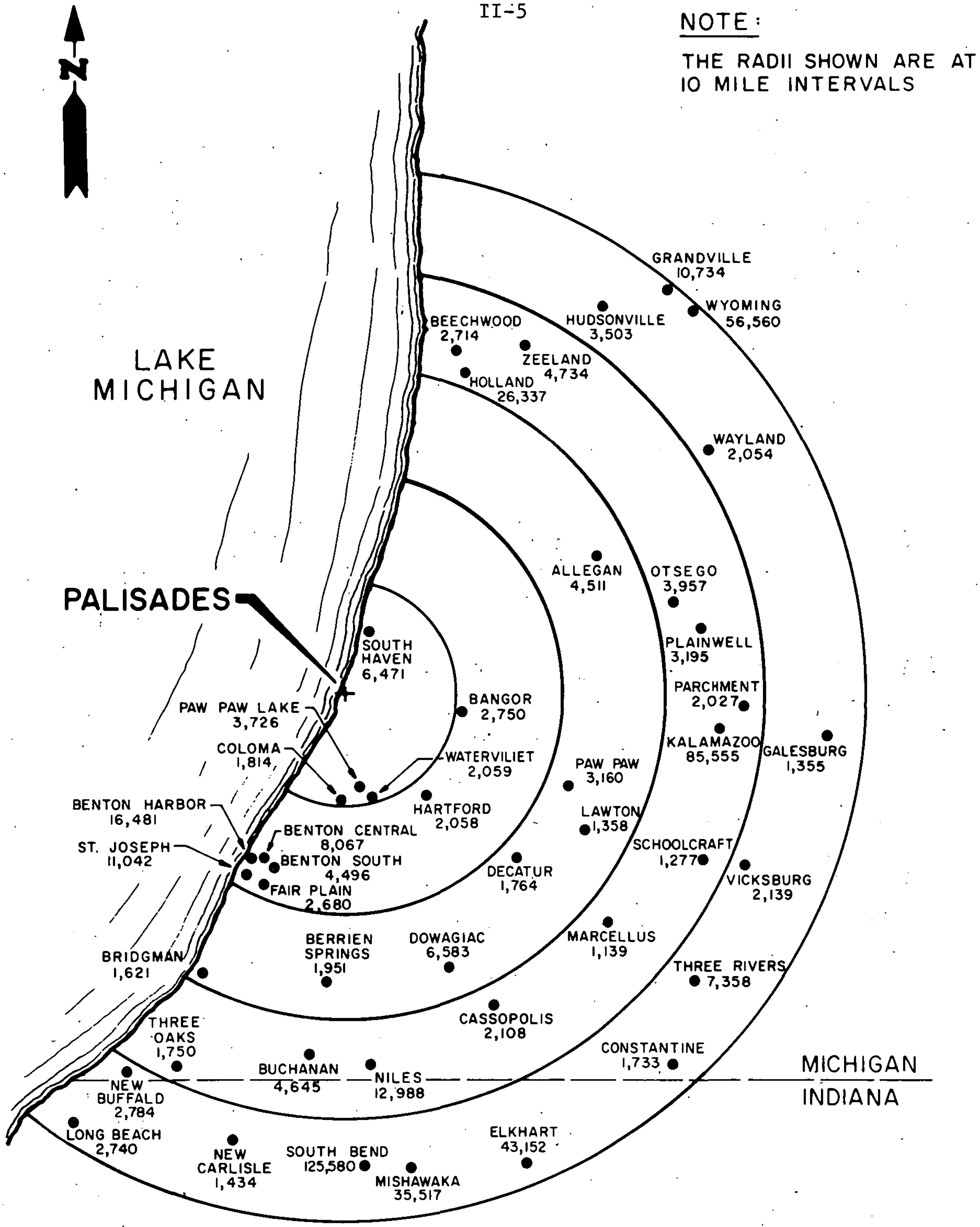


Fig. II-3
PALISADES PLANT
POPULATION CENTERS
OVER 1000
0-50 MILES
1970 CENSUS

of Van Buren County, a population of about 83,000 is projected for the year 2010 - a growth of about 56% over 1970 figures.[3] The latest available employment statistics[3] show a county work force of 17,179 people, who are mainly involved in manufacturing (5,846); agriculture, forestry, and fisheries (2,472); construction (1,140); utilities (818); and mining (17). Section 2 of the Applicant's Final Safety Analysis Report and the applicant's Environmental Report[4] outline the statistics of crop production and livestock as well as the names and types of industries in the area surrounding the Palisades site. The unincorporated town of Covert is the community nearest to the site (3-1/2 miles) that contains such facilities as schools. The nearest airport is the South Haven Municipal Airport, 3 miles from the Plant, which handles relatively small aircraft but is the major air transportation for Van Buren County.[1] A larger commercial airport is on the outskirts of Benton Harbor and St. Joseph. The Van Buren County Planning Commission[1] discusses the growth potential such as trends in agricultural production, land pattern use, economic factors of the county, residential use, commercial use, and industrial uses in the county. The population near the site, particularly in South Haven Township, is growing rapidly with expansion of the city of South Haven. Greater urbanization in the region is occurring due to the growth of South Haven and to the convenient access for transportation along the I-196 "Corridor." Residential, commercial, and industrial activities have all been increasing as have the real estate values in this area of Van Buren County.

During early site development in 1966, the applicant coordinated site land use with the State of Michigan to permit optimum use of the area for the respective purposes of the Van Buren State Park and electric generating site. This coordination lead to a land exchange between the applicant and the State. The land offered to the State included 360 feet of Lake Michigan frontage immediately south of and adjacent to the partially developed picnic and day-use area of the State Park. It also completed the consolidation of ownership necessary for park use of an area dedicated for that purpose.[5]

Much of the area around the site is devoted to recreation and tourism and, consequently, has a fluctuating and seasonal population. During most of the year there are only about 40 residents within 1 mile of the site and 1,200 people within 3 miles. No residences are within the boundaries of the site. Recreational activities at Van Buren State Park, Covert Township Park, and private resort areas along the beach result in a visiting population of approximately 2,000 people per day during the summer months. This transient population is expected to increase when permanent camp sites are constructed in Van Buren State Park.

The coastal waters of Lake Michigan in the vicinity of the Palisades site also attract visitors for aquatic recreation. There are harbors for small craft at South Haven and Benton Harbor.

Two 1,100-MWe nuclear power plants (Donald C. Cook No. 1 and No. 2) are to be constructed by another utility (Indiana and Michigan Electric Co.) at Bridgman, Michigan, approximately 30 miles south of the Palisades site.

D. HISTORIC SIGNIFICANCE

The site has been considered in accordance with the requirements of the National Historic Preservation Act of 1966, 16 U.S.C. § 470 f. (Supp. 1970) to determine whether any historic landmarks will be affected by the Palisades Plant location. No landmark in the vicinity of the site is listed in the National Register of Historic Places,[6] and the applicant knows of no Federal, State or local historical landmark that would be affected by the Plant.[4] As recommended by the Advisory Council on Historical Preservation, the Historic Preservation Officer for the State of Michigan has been contacted and his comments concerning the effect of the undertaking upon historical and archeological resources are enclosed in this Statement as Appendix XII-1, 10. The Department of the Interior also has commented that the existing Plant should not directly affect any existing or proposed unit of the National Park System nor any site eligible for registration as a national historic, natural or environmental education landmark (see Appendix XII-1, 7).

The sand dunes in this region are thought to be excellent examples of a land-water complex that has been developed during the last 10,000 years, and, therefore, of significant value as a natural geological site.

E. ENVIRONMENTAL FEATURES

1. Surface Water Hydrology

The reactor site is located within two drainage basins; one leads into Lake Michigan and the other into Brandywine Creek. This creek is fed largely by runoff and, in combination with its tributaries, drains an area of 17 square miles before it enters Lake

Michigan through a gap in the dunes 3,000 feet south of the site. The soil in the drainage basin is impermeable so that the runoff of nearly all of the rain and snow in this region enters Lake Michigan. Some dry weather flow probably due to groundwater seepage also occurs. An estimate of the annual extremes in flow rate was made by Giroux et al,[7] and these were found to vary from a high of 11.4 cubic feet per second (cfs), or 5,130 gallons per minute (gpm), to a low of 0.90 cfs, or 405 gpm. Some sections of this basin have been modified by man-made canals to facilitate drainage of swampy areas and ponds. These channels usually follow the paths of sluggish tributaries of Brandywine Creek.[4]

2. Lake Hydrology

Lake Michigan is the sixth largest freshwater lake in the world and has a surface area of 22,400 square miles, a shoreline of 1,661 miles, a volume of approximately 1,114 cubic miles, and a total discharge of about 1.74 x 10^{12} cubic feet per year of which 94% flows through the Mackinac Straits and 6% is diverted to the Chicago River. The lake basin can be roughly divided into a southern basin (south of a line between Milwaukee and Grand Rapids), a middle "shallow" area, and a northern basin. The Palisades site fronts on the southern basin, which has a maximum depth of 540 feet. There is a deficiency of watershed area contributing to this southern basin, and evaporation exceeds precipitation during the warmer half of the year. Dissolved solids tend to be concentrated somewhat by the movement of water from the northern basin across the central sill and into the dead-end southern basin. Such circulation results in a flushing time of approximately 25 years for the southern basin.[8]

The average height of Lake Michigan is about 580 feet above sea level, and the maximum recorded changes in lake level have been approximately ± 3 feet. Unusual surges (seiches), as high as 6 to 8 feet have been observed; however, such events cannot be predicted and exist for only a very brief period.[8] A profile of the lake depths has been included in the applicant's Environmental Report.[4]

Lake currents are principally caused by the cumulative effect of wind action over periods as long as 10 days. A study by Hough et. al.[8] indicates that currents near shore can be predicted from the records of winds. Thus, when the wind is from the southwest quadrant (30% of the time), the currents are along the shore in a northerly direction; when the wind direction is from the northwest quadrant (24%), the currents are along the shore in a southerly direction; and when the winds blow from inland (40%), the result is offshore currents. Only 6% of the time is there a calm. Subsurface and offshore currents are modified to some degree by the rotation of the earth and the temperature cycle of the lake water. During the winter the surface of the lake is altered by the formation of ice fields, primarily along the shores.

The temperature regime of Lake Michigan is important in considering the impact of thermal and chemical discharges into the lake, because of the importance of temperature-induced density currents in lake mixing. It is convenient to divide the lake into two distinct, major zones in discussion of the temperature regime, the inshore zone and the open lake or offshore zone. The inshore water zone is defined as that volume of water which lies between the shoreline and the 100-foot depth contour (about 5 miles offshore); the open lake is all water beyond the 100-foot depth contour. Open lake temperatures range from a high of about 75°F (24°C) in mid-August to a low of approximately 35°F (1.7°C) in January or February. The surface temperatures of the inshore zone range from about 32°F (0°C) in winter to over 75°F (24°C) in summer.[9]

Lake Michigan is dimictic (two circulation periods per year), with overturns, or nearly complete circulation, occurring in early winter and early spring every year in the southern basin. During this circulation period (approximately a month in duration),[9] the lake is isothermal and water in the southern basin is mixed from top to bottom (Fig. II-4A); the northern basin may not mix to the bottom.[9]

As air temperatures decrease in winter (late December-early January), the shallow inshore waters cool faster and reach temperatures below that of maximum density [39.2°F (4.0°C)], while the offshore deep waters are above 39.2°F and continue to mix. In the mixing zone between the shallow, colder inshore waters and the warm, offshore water mass, the water is at maximum density and thus sinks (Fig. II-4B). This sinking water mass is replaced through surface convergence of inshore and offshore waters, which leads to continued mixing and sinking. This convergence and sinking of the cold water in this area creates two distinct flow patterns as shown in Fig. II-4B. The shearing stress resulting from the interaction of these two flow patterns should then induce mixing between the two water zones (the inshore water zone and the offshore water zone) and thus some transport of material across the "thermal bar" should exist. This concept of the physics of the thermal bar phenomenon is shared by P. W. Pritchard[27] and J. C. Ayers[28] and by Elliott and Elliott[29] who have demonstrated it in the laboratory.

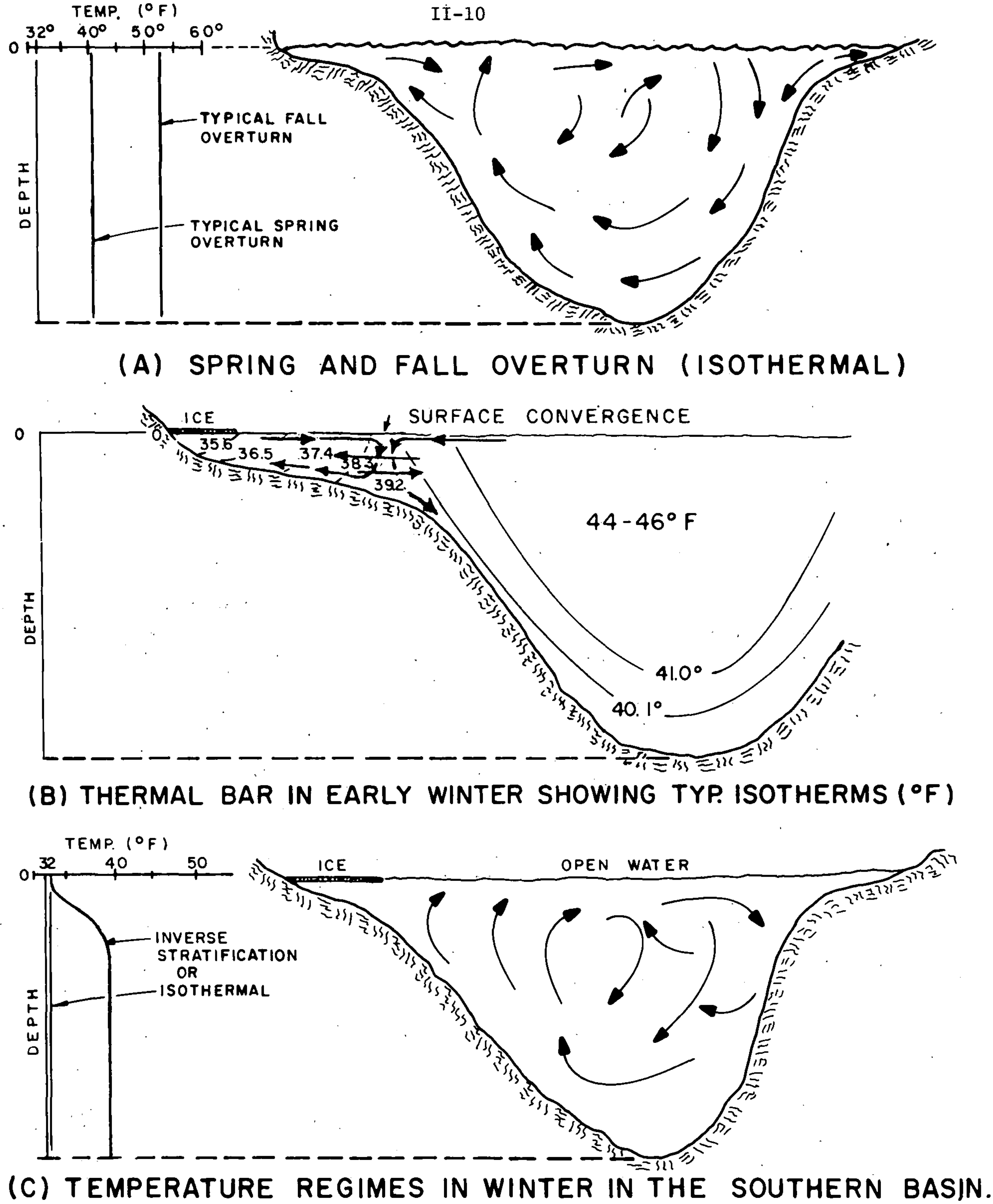
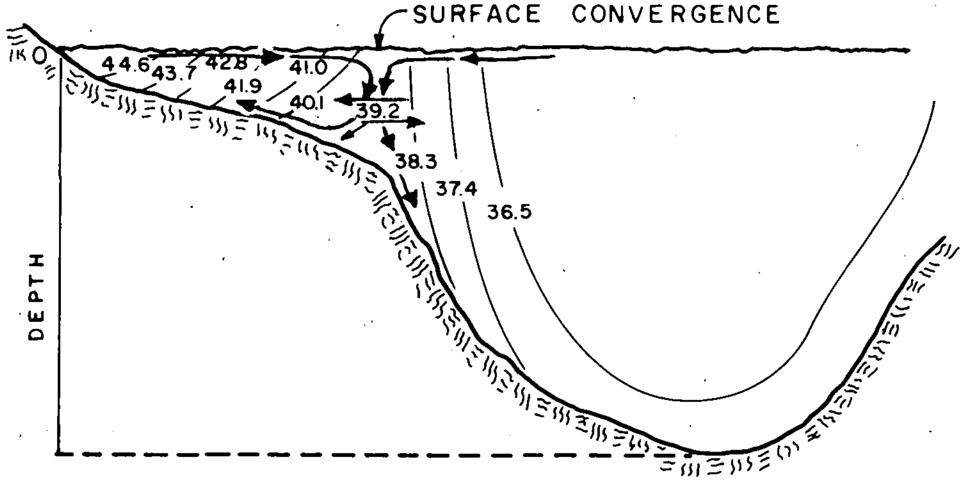
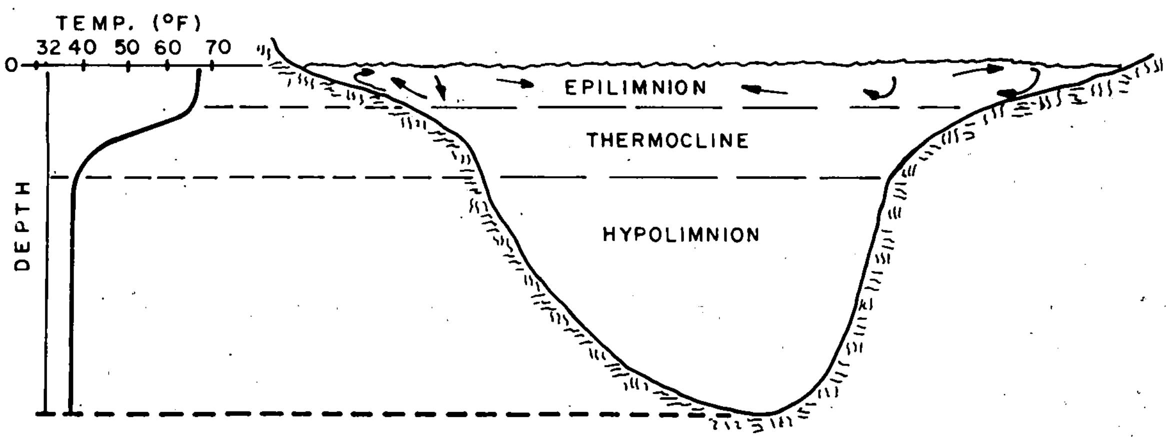


Fig. II-4 A,B & C

TEMPERATURE CYCLE OF LAKE MICHIGAN SHOWING THE DEVELOPMENT OF THE THERMAL BAR IN NEAR-SHORE WATERS & SEASONAL CHANGES.



(D) THERMAL BAR IN SPRING SHOWING TYP. ISOTHERMS (°F)



(E) SUMMER STRATIFICATION

Fig. II-4 D & E
TEMPERATURE CYCLE OF LAKE MICHIGAN SHOWING THE DEVELOPMENT OF THE THERMAL BAR IN NEAR-SHORE WATERS & SEASONAL CHANGES.

The Environmental Protection Agency (EPA) states in Appendix XII-5 that "although the hydrodynamic characteristics of this barrier are not understood fully, there is a reason to believe that it may prevent the exchange of heat and pollutants between the shallow near-shore water and the deeper off-shore water." Thus, according to EPA a greater concentration of pollutants should occur confined to the inshore waters.

The applicant has responded by stating that it is not familiar with any evidence suggesting that pollutants accumulate in the in-shore water during the period of the so-called "thermal bar", or that if they do, that the thermal discharge from a power plant would accelerate pollution effects. See Appendix XII-13 for further comments by the applicant on this subject. To provide a better understanding of the thermal bar phenomenon in Lake Michigan, and its influence on nearshore limnological characteristics, the applicant is cosponsoring, with American Electric Power Service Corporation and Northern Indiana Public Service Corporation, a study of the thermal bar by the University of Michigan. A study report[30] on the field work has just been prepared in which a series of multispectral aerial infrared scans of thermal plumes of several power plants and the formation and movement of the thermal bar were taken over a period of several weeks along the eastern shore of Lake Michigan and observations made regarding mixing of inshore and off-shore waters. The results indicate that no distinct water mass relationship exists between any of the three plant discharges studied and any changes in the thermal bar or currents in Lake Michigan in general.

The Michigan Water Resources Commission believes that the thermal plume from the Palisades Plant will develop a heat density underflow during winter which can lead to disruption of the thermal bar. In Appendix XII-9 the MWRC discusses the details of its opinions on the thermal bar. As stated above, the staff believes the shearing stress from two flow patterns will lead to some transport of material across the thermal bar. See Chapter XII for further discussion on this subject.

As cooling and mixing of the water in winter continue, offshore waters cool to the temperature of maximum density (39.2°F) and become nearly isothermal at about that temperature. In years of severe winters, surface waters may cool to below 39.2°F, thus creating an inverse stratification during ice cover (Fig. II-4C). As ice forms on the surface, and as snow on the ice blocks out solar radiation, surface waters may reach temperatures near 32°F, thus becoming less dense than deeper, warmer waters near 39.2°F. This phenomenon is uncommon in the southern basin of Lake Michigan but occurs more frequently in the northern basin in severe winters. Ordinarily, there is an intermittent ice cover extending a relatively short distance from shore (1 to 2 miles) in the southern basin and the open lake remains ice-free. Thus, the lake is essentially isothermal at 35.6°F (2°C) or below, and mixing occurs from top to bottom during storms (Fig. II-4C).

In early spring, warming of surface waters results in the shallow inshore waters heating up faster than offshore waters. This is because of the high surface-to-volume ratio of inshore waters compared with that of the offshore waters. These inshore waters reach temperatures above that of maximum density while offshore waters are below the temperature of maximum density. In the inshore area between these water masses, a water mass at 39.2°F sinks and mixes through surface convergence as colder, lighter water is warmed (Fig. II-4D). This phenomenon is the spring thermal bar condition, the reverse of the winter thermal bar (Fig. II-4B) in that the warmer waters are inshore and the colder waters are offshore. The thermal bar in spring may persist for as long as 6 weeks,[10] because the shallow inshore waters gain heat much faster than the deeper offshore waters. In midsummer, the temperature differential between the two water masses may be as much as 9°F (5°C). In addition, chemical studies have shown distinct differences in water quality between the inshore and offshore waters, which reflects the degree of separation of these two water masses.[9]

As heating and mixing of surface waters continue, the thermal bar moves progressively offshore until vertical thermal stratification is established across the entire lake in summer (Fig. II-4E). In Lake Michigan the epilimnion varies from 10 to 15 feet in thickness in late spring or early summer to over 200 feet in thickness in late fall.[11] Temperature in the epilimnion may reach 75°F. The thermocline is normally about 20 feet thick but ranges from 3 feet (during storm periods) to 49 feet in thickness.

The Palisades Plant will use nearshore waters for cooling the condensers and will then discharge this water into the lake at the surface. Intake temperatures will vary both daily and seasonally, due to lake mixing resulting from temperature- and wind-induced currents, seiches, and thermal stratification as discussed previously. Discussion of the thermal discharges and their potential impact on the environment is presented in Section III.D and Chapter V, respectively.

3. Geology

Bedrock under the Palisades Plant area is the Mississippian Coldwater shale that lies at a depth of about 150 feet below the lake level. The shale surface was eroded by streams prior to several major glacial advances and was still more deeply eroded (below sea level) by the ice. Local bedrock is a compact blue, gray, or locally red shale. Many other rocks of the Paleozoic era and their debris were mixed and laid down by glaciers. The lake-border moraines represent the last layers of a cake of about 90 feet of compact clay till that overlies the bedrock.

The till, in turn, is overlain by about 30 feet of gray or silty sand laid down in Lake Michigan and in its predecessor lakes. This silty sand is well-compacted and provides the foundation for the heavier structures of the Plant. The silty sand is overlain by generally loose dune sand that is more permeable than the underlying materials and suitable for foundations only after it has been compacted. The sand dunes that form the major feature of the surface topography rise to elevations of 130 feet or so above the lake level. Aerial photographs and Appendix II-1, Fig. 1 reveal that most of the dunes are now fixed by forest vegetation, but the white areas represent sand that is still actively blowing or has been stabilized by pioneer plants and a succession of more protective vegetation stages in recent decades.[12-14] The highest dune summits form small conical hills and ridges separated by undrained depressions. Dune ridges nearly parallel to the beach have been eroded by waves during geological periods of high lake level. Bending of the ridges by eastward blowing along certain "blowout" axes have left a remarkable series of V-shaped, U-shaped, and parabolic landforms that are of geologic renown. The band of dunes is about 1 mile wide and includes ridges of several lake states. To the east of the dunes is the open valley of Brandywine Creek, which, in turn, is bordered on the east by the gentle undulating lake-border moraine.

No faults have been mapped in the vicinity of the site, and only one earthquake epicenter has been reported within 50 miles since 1804. The regional faulting and general seismic activity appears to be related to deep-seated geologic structures that are some 150 miles from the Palisades Plant site.[4]

4. Groundwater

Within the Brandywine Creek basin, the subsurface drainage is generally westward toward Lake Michigan with a gradient of about 13 feet per mile.[7] The area underlying the dune area represents a free groundwater unit with a level controlled by Lake Michigan itself. In most of the basin the impermeability of the sediments minimizes seepage downward, and even water movement downward into the material underlying the dunes is very slow. From a drilling program on the site, it was found that the groundwater levels ranged from 599 to 580 feet above sea level.

5. Meteorology

The Palisades site lies in a region of humid continental climate that features cool summers, rainfall most prevalent in autumn, and about 80 days of snow cover per year. This region is also along the route of major air movements from the northwest to the southeast in the colder months, and the passage of such a large number of fronts results in very favorable dispersion characteristics and ventilation of the land area below.[4] The weather over land that is adjacent to Lake Michigan is modified by the annual cooling-heating cycle of the lake.

Annual rainfall averages 34 inches, with a mean low in February and mean high in September of 1.5 inches and 3.5 inches, respectively. There is a serious icing in the area about once every 2 years.[4]

A nearly continual air movement exists along the coast; the surface winds are basically westerly, although the direction varies considerably because of the migratory pressure centers. Monthly wind-roses for the period September 1967 to August 1968 are presented in Appendix D of the applicant's Final Safety Analysis Report. On the shoreline the usual wind velocity is about 12 miles per hour (mph) at an elevation of 32 feet and 15 mph at 256 feet. Although tornadoes are relatively common farther inland in Michigan, Indiana, and Ohio, they are very rare along the lake front, probably due to the stabilizing effect of the air over Lake Michigan. There were no tornadoes within 1 mile of the lakeshore during the period of record (1897-1965).

F. ECOLOGY OF SITE AND ENVIRONS*

1. Terrestrial

The area of the sand dune shore belt is forested except for the bare sandy beach, naturally denuded or deforested dune areas, or where construction has taken place. The dominant forest community type on the site area is composed of red oak, sugar maple, and beech.[15] The upper stratum consists of a closed canopy of the dominant

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* Various aspects of ecological processes and systems are described further in Chapters IV and V and Appendices of this Statement and will only be introduced here.

second-growth red oak and sugar maple with an interspersion of several other species, including beech, black cherry, ash, white oak, and basswood (see lists in Appendix II-1, Fig. 1). Variants of the dominant mixed mesophytic vegetation type occur throughout the area. On some younger blowout surfaces, white pine and red oak are dominant. Hemlock trees occur in the upper stratum of north-facing slopes; e.g., next to the proposed southernmost cooling tower. The species composition of lower vegetation and animals of these dune communities depends on several factors including topography (i.e., beach, foredune, protected slope, etc.), water table (wet depressions vs. more dry conditions), and history of disturbance (fires, man-made disturbances, etc.)[12]

Throughout the sand dune landscape, several so-called blowout areas exist where either natural or man-made disturbances have caused renewed wind action and denudation of the forest community. The sandy soil has become exposed to wind erosion; the eroding sand is still covering vegetation on the leeward side of the blowout areas. The vegetation in these blowout areas is sparse in the early plant successional stages, with beach grasses and forbs (wormwood, milkweed, goldenrod, evening primrose) being the common species.[13] Appendix II-1, Fig. 1 shows further details of the various vegetation types (including minor species on disturbed areas) and their distribution at the Palisades Plant site.

Scientific evidence on the natural order and rates of ecosystem development and recovery have lent special fascination and interest to dune areas. Thus the area around the Palisades Plant and several Lake Michigan dune parks are famous as rich habitats for plant growth and production of animal communities intricately dependent on the plants. The diverse plant communities and diversity of plant species within these communities provide both food and cover for wildlife species. Plants, the primary producers of organic matter, provide seeds, buds, and fruits for squirrels, deer, racoons, ruffed grouse, and songbirds. The lower stratum provides browse for white-tailed deer and cottontail rabbits. Many of the ecosystems are close enough to provide year-round cover for several other vertebrate species and invertebrate phyla. Dense pine stands in the area (outliers of northern forests) provide cover during winter months for deer, grouse, rabbits, and other small wildlife species. The blowout areas of actively moving sand provide openings in the forest communities and increase the edge habitat (transition zone between plant communities) of the entire area, which is known to be heavily utilized by many species of birds and other wildlife.

The early plant successional stages in the blowout areas provide summer habitat for deer, rabbits, and many small mammals. Carnivores, such as the red fox, tend to hunt both these open areas and the forest edge for small wildlife species. The diversity of plant communities provides an excellent food supply and resting area for songbirds also. The sandy beach and low dunes parallel with the lake shore provide resting and feeding spots for water birds such as gulls and terns. The wildlife present in the vicinity of the Palisades Plant site is listed in Appendix II-1, Table 1. Over fifty species of wildlife, including small mammals (moles, squirrels, chipmunk), fur and game mammals (deer, fox, rabbit mink, etc.), upland game birds (grouse, pheasant, quail, etc.), waterbirds (gulls, tern), birds of prey (owl, bald eagle, golden eagle, hawks), and songbirds are known to be present in the area at various times throughout the year.[15] The bald eagle has been observed in the area of the Palisades Plant at various times of the year and is on the list of endangered species.[16]

2. Aquatic

Although the ecology of Lake Michigan in the immediate area of the Palisades Plant has not been extensively studied, available data indicate that the fauna and flora collected in this area are typical of areas long studied on the east side of lake.[17-24] Major changes have occurred in the fish populations in Lake Michigan, and the lake is showing some signs of eutrophication.[17] However, the biological characteristics of most of the lake are those generally associated with oligotrophic bodies of water (low in nutrients).

Generally, Lake Michigan has low algal populations compared with those of most surface waters, with centric diatoms predominating.[17] During the summer the southeast sector of the lake, however, contains algae close to the shoreline of the type commonly found in eutrophic situations[18] (rich in nutrients). There is an apparent relationship between the areas of the lake shore where nuisance algae occur and the proximity of sources of plant nutrients contributed by major tributaries.

The region near the Palisades Plant has not received extensive plankton study until recently. There are long-term plankton records for major municipal water intakes (e.g., Chicago), but these provide evidence only of local changes, particularly those peculiar to the heavily industrialized and urbanized southwest sector of the lake. The State of Michigan began to monitor lake plankton in 1969, including one station near South Haven.[18] Pre-operational ecological studies at the Donald C. Cook plant site south of Benton Harbor (about 30 miles south of Palisades) have provided the most detailed information.[19] Plankton studies were conducted for the applicant by Beak Consultants, Inc.; however, the surveys conducted supplied only a narrow range of baseline data. Seasonal occurrence of major algal groups and species of the phytoplankton are listed in Appendix II-1, Tables 2 and 3.

No clear succession of algal species through the year nor clear understanding of their spatial distributions in the area of the Palisades Plant has been identified. Some species are largely contributions by tributaries, including Actinastrum sp., Pediastrum sp., Scenedesmus sp., and Melosira islandica from the nutrient-rich St. Joseph River, and Navicula spp. from the relatively nutrient-poor Black River.[18] The river plumes can be identified in the open lake waters by observing accumulations of these species. The blue-green algae appear to be more abundant in near-shore areas than in mid-lake.[18]

The zooplankton in Lake Michigan is dominated by cladocerans and copepods with the most abundant genera being Daphnia spp. and Diaptomus spp.[20-21] Shifts in abundance of the dominant groups of zooplankters have occurred over the past 40 years as a result of decreased predation pressure on the zooplankton populations.[22] This decreased predation pressure is apparently the result of major changes in the fish populations of Lake Michigan. As a result, the zooplankton is now dominated by larger species.[22] Appendix II-1, Table 5 is a list of zooplankters collected in surveys from two areas of Lake Michigan.

The benthic invertebrate fauna in the area of the Palisades Plant were surveyed by Beak Consultants, Inc. Their survey data[23] on species composition and density of benthic invertebrates agree with data obtained by other investigators. (See Appendix II-1, Table 4 for a species list of benthic macroinvertebrates as collected in the area of the Palisades Plant). The major taxonomic groups of benthic invertebrates in this lake include amphipods, oligochaetes, aquatic Diptera (primarily Chironomidae) and freshwater clams (Sphaeriidae). Chapter V of this Statement contains a more detailed discussion of the benthic fauna in the area of the Palisades Plant.

Salmonids were the dominant fishes in Lake Michigan until the invasion and population explosion of the alewife during the 1950's. Alewife now dominate the fish biomass and have been responsible for major changes in the higher trophic levels of the food chains in Lake Michigan. Other factors which have contributed to these changes include the reduction of lake trout populations due to the lamprey, and introduction of coho and chinook salmon into the lake.

In preoperational surveys conducted by the State of Michigan[24] in the area near the Palisades Plant, 28 fish species were collected (a species list of fishes collected in the area of the Palisades Plant is in Appendix II-1, Table 6). Several of the principal fish species are discussed in detail in Chapter V and Appendix V-2.

Although Lake Michigan is showing signs of eutrophication and major changes have occurred in the fish populations, the lower levels of the food chain appear to be unchanged from that generally described by Bersamin[25] in 1958. Even though Bersamin was concerned primarily with the food chain of the chubs (Coregonus spp.) in Lake Michigan, his information and that from other sources can be used to outline the general trophic structure for the lake at present (Fig. II-5). In particular, Bersamin noted the great importance of crustaceans to the trophic structure of the entire lake. In a study of the food habits of 30 fish species in Lake Superior, which has a biota almost identical to Lake Michigan,[17] Anderson and Smith[26] concluded that crustaceans constituted the main part of the diet for most fish species, at least during some phase of their life history. Thus, the productivity of fish populations is highly dependent on the productivity of crustaceans in this lake. A generalized food chain for Lake Michigan would be: production of green algae, primarily diatoms, which are grazed by crustacean zooplankters. These crustaceans are in turn grazed on by plankton feeders, which include nearly every species of fish in Lake Michigan, at least during some phase of their life history. Many of these fish species later become piscivorous (fish eating) and feed on other fish species when they reach a certain size (coho salmon feeding on alewife, etc.).

The benthic invertebrates in the lake rely for their food source on planktonic materials (phytoplankton and zooplankton) produced in the photic zone which die and settle to the lake bottom. The benthic invertebrate species, in turn, are consumed by the deep-water fishes such as the lake trout and the cisco or lake herring.

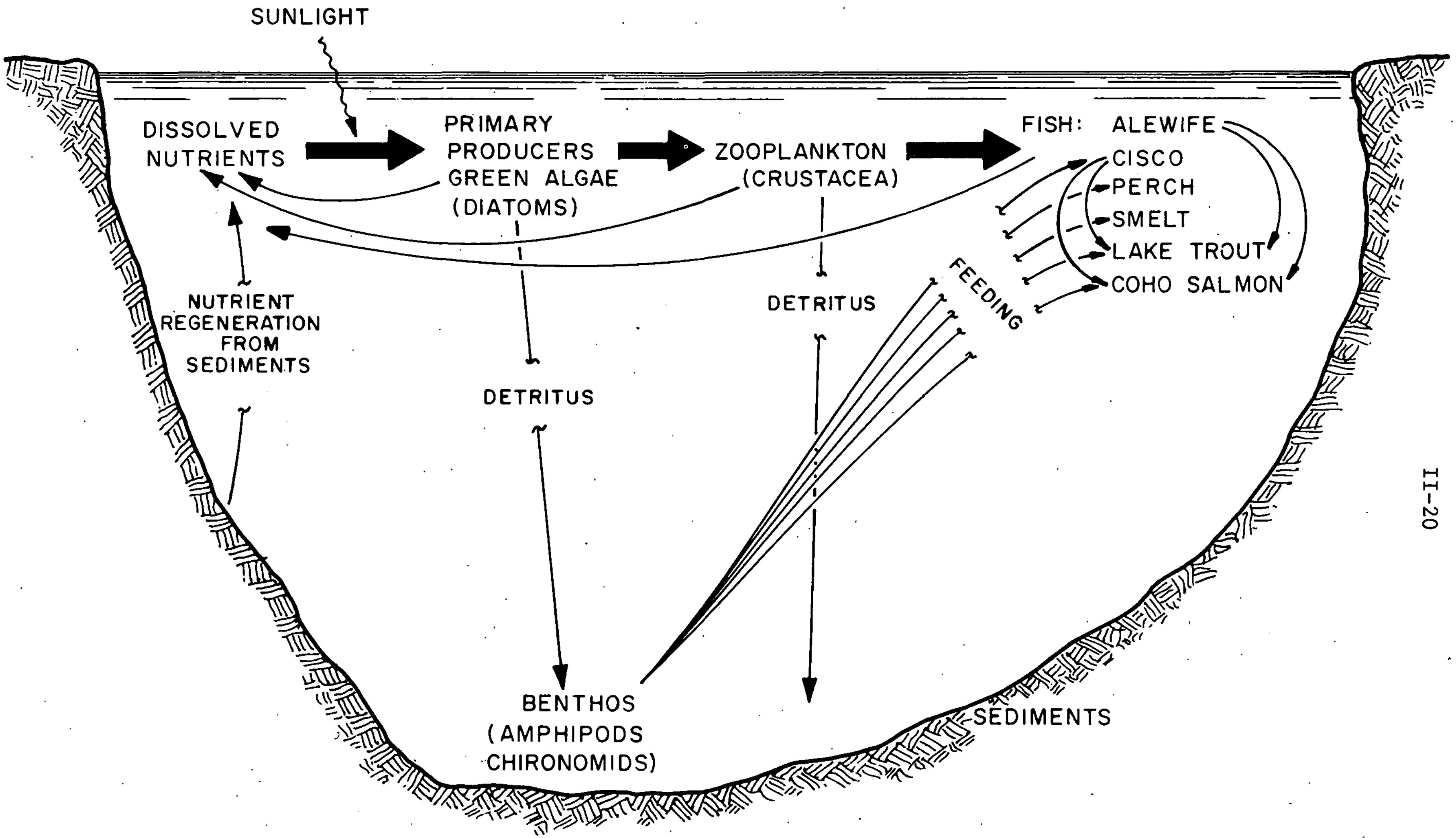

Fig. II-5
GENERALIZED SCHEMATIC MODEL OF THE TROPHIC STRUCTURE OF LAKE MICHIGAN

REFERENCES FOR CHAPTER II

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2. "Final Population Counts - 1970 Census of Population," Reports PC (VI)-16 (Indiana) and PC (VI)-24 (Michigan).

3. Chamber of Commerce, Greater South Haven Area, September 1971.

4. Consumers Power Company, "Environmental Report for Operating License Stage for Palisades Plant," October 9, 1970.

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III. THE PLANT

A. EXTERNAL APPEARANCE

The appearance of the Palisades Plant is shown photographically in Fig. III-1. The cylindrical building is the reactor containment building. The large rectangular building parallel to the shoreline of Lake Michigan is the turbine building. The office and auxiliary facilities are situated east of the north end of the turbine building so that, except for the containment building, the complex is L-shaped. The principal visible characteristics of the reactor plant--its cylindrical and box-like shapes, its gray concrete surfaces and red ceramic tiled entrance panels, its marked vertical and horizontal lines--are in sharp contrast with those of the visitors' center, which lies a few hundred feet inland from the Plant. The architecture of the structure of the visitors' center employs rough-sawn unfinished wood for the exterior surfaces of the building. The structure includes numerous angled surfaces that tend to identify it with the adjacent sand dunes.

The proposed cooling towers will consist of multiple-cell units, approximately 500 to 1,000 feet south of the existing Plant (see Fig. II-2). Each of the two rows will be 650 feet long, 65 feet wide and 50 feet high. These towers will lie approximately 3,000 feet from U.S. Highway 31, and as near as 300 feet from the shoreline of Lake Michigan. The modified liquid radioactive waste system will be housed in a new building, now under construction. Upon completion, it will appear as a 30-foot high structure, north of and connected with the existing auxiliary building.

The Palisades Plant is shielded from view from both U.S. Highway 31 and Interstate Highway I-196 by sand dunes; it is visible, however, from the lake side of the site as shown in Fig. III-1. The proposed cooling towers also will be shielded from view from both highways but visible from the lake side.

B. TRANSMISSION LINES

As mentioned in Section I. B., the energy to be generated at Palisades will be delivered to the applicant's system through a 40-mile 345-kV line to the Argenta Substation and to the American Electric Power Company through a 0.6-mile 345-kV tie line to the Indiana and Michigan Electric Company. The Palisades-West Olive line (0.6 miles) begins at the Palisades Substation on the same strip as the Palisades-Argenta 40-mile line. These two lines were constructed in 1969 and consist of lattice-type steel towers anchored to concrete footings. The Michigan Public

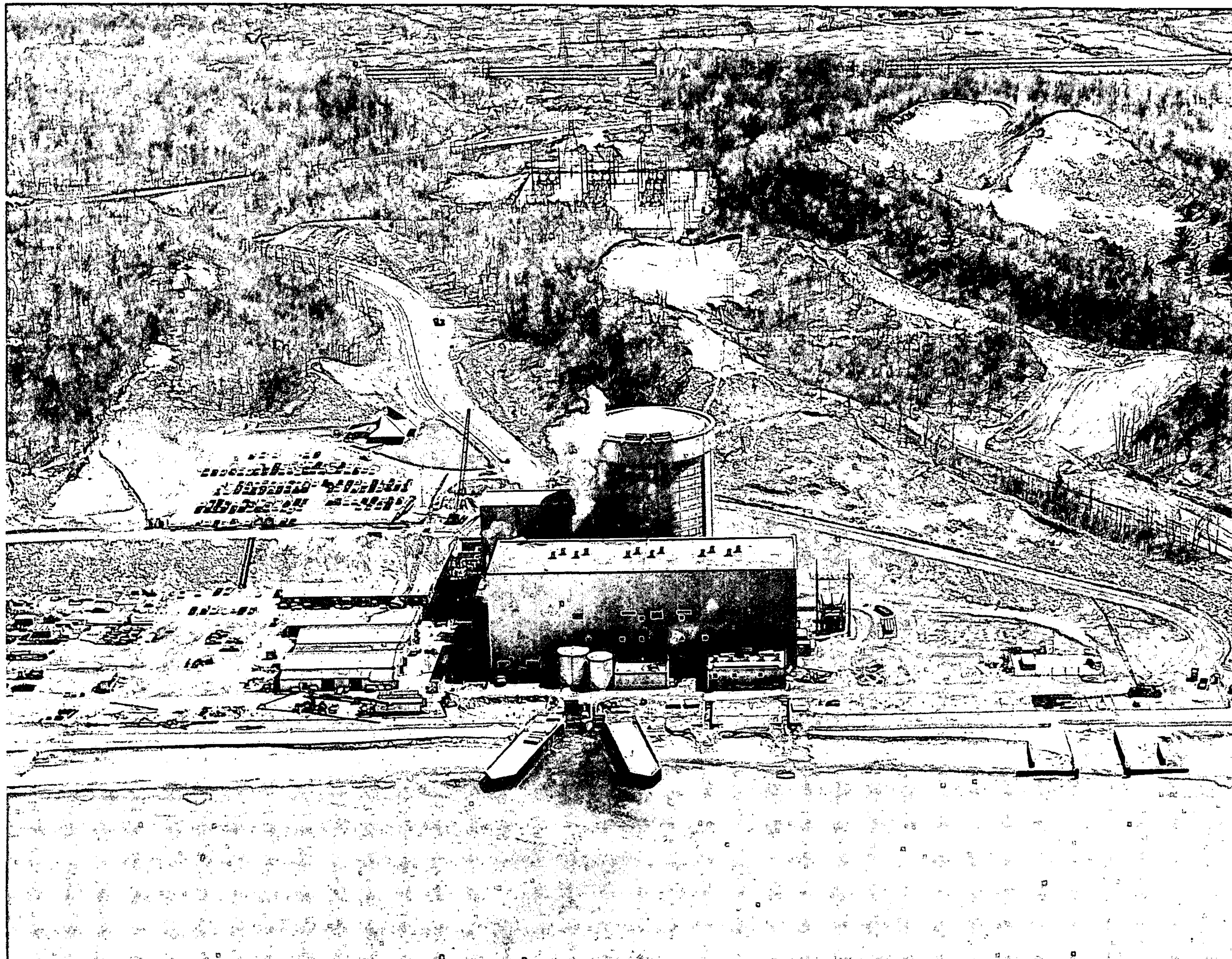


Fig. III-1

Service Commission granted approval for their construction. A map showing the transmission lines of the applicant's integrated Electric System is presented in supplemental information[18] supplied by the applicant.

Since the route to the interconnection to the Indiana and Michigan facilities passes close (0.6 miles) to the Palisades Plant site, the transmission lines connecting the Palisades Plant to this distribution system involved a clearing of a 150-foot wide transmission corridor over the sand dunes from the Plant bus bar to a switchyard which was part of the 345-kV interconnection (see Figures II-2 and III-1). The total area cleared for the Palisades-West Olive line was about 5 acres.

The Palisades-Argenta route running east and northeast to the Argenta Substation located 1 mile east of Plainwell, Michigan, is an extension of the 345-kV distribution system that the applicant and Detroit Edison Company[1,2] had constructed between the major power plants of the Michigan Power Pool to provide the electrical energy to the proper load center as the demand shifts from one load center to another, daily or seasonally. The right-of-way for the first 4.5 miles is 1,320 feet in width; for the next 34 miles, it is 350 feet in width and for the final 1.5 miles it is 471 feet in width. The total area needed for this 40-mile corridor is 2,250 acres.

The 40-mile line is located on generally flat to gently rolling terrain used primarily for agricultural purposes with scattered orchards, private dwellings and commercial property along the route. Where the right-of-way lines are located on farmland, farmers have leases from the applicant to allow continued use of the land for agriculture. Some land used for orchards was disturbed to permit tower construction. Resort lakes were bypassed during construction of the transmission lines.

C. REACTOR AND STEAM-ELECTRIC SYSTEM

The Palisades Plant employs a closed-cycle, pressurized, light water-moderated and water-cooled nuclear reactor as its source of heat for generating steam to produce electricity. The nuclear steam supply system as shown in Fig. III-2 was designed and supplied by Combustion Engineering, Inc. Bechtel Corporation was the architect-engineer. The Plant is designed to initially operate at a power level of 2,200 thermal megawatts (MWt), producing 700 net electrical megawatts (MWe), with an ultimate predicted operating level of 2,600 MWt and an electrical output of 821 MWe.

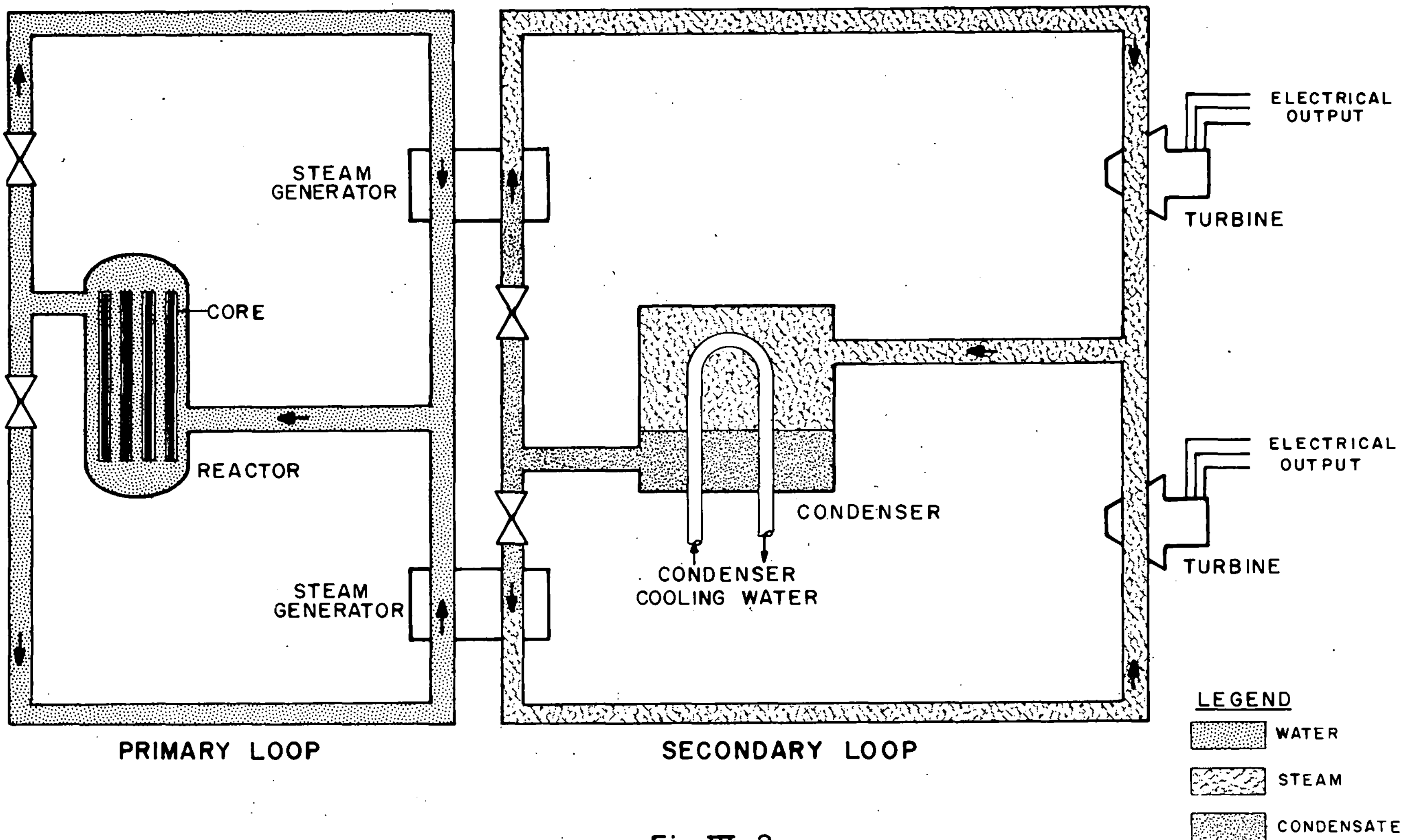


Fig. III-2
REACTOR AND STEAM-ELECTRIC SYSTEM
PALISADES PLANT

The reactor is fueled with slightly enriched uranium dioxide in the form of ceramic pellets. These pellets are contained in zircaloy-clad tubes, the ends of which are sealed by welded plugs. Water serves as both the moderator and the reactor coolant. Control rods, consisting of silver-indium-cadmium absorber material clad in stainless steel, are used to control the short-term reactivity of the reactor, while the long-term reactivity is controlled by adjusting the concentration of boric acid dissolved in the reactor coolant/moderator water.

Heat generated by the reactor core is transferred by means of pressurized water coolant through two separate closed-cycle loops to two steam generators (Fig. III-2). The loops are referred to as primary coolant loops and are designed for a pressure of 2,500 pounds per square inch absolute (psia) and a temperature of 650°F (343°C). The reactor core is located inside the concrete shielded reactor vessel which, with the primary loops, is located inside the concrete containment building.

The secondary coolant loop, which is kept at a pressure of 1,000 psia, utilizes the heat from the steam generators to convert water to steam, the steam being used to drive the turbine. After passing through the turbine, the "spent" steam is condensed and the condensate, after purification and reheating, is pumped to the steam generators to repeat the cycle. The heat from the condenser is then dissipated to the environment as described in Section III.D.1.

D. EFFLUENT SYSTEMS

1. Heat Dissipation Systems

a. Present Open-Cycle Once-through Cooling System

The Palisades Plant, as presently constructed, has a once-through cooling system to dissipate waste heat from the turbine condensers and service water cooling system to the environment. A flow diagram of this once-through system is shown in Fig. III-3. Water is pumped from Lake Michigan at a flow rate of approximately 405,000 gallons per minute (gpm), or 900 cubic feet per second (cfs), into an intake structure, passed through the turbine condenser and auxiliary plant cooling systems, and returned to Lake Michigan, via a 108-foot long discharge canal at the shoreline. At an operating level of 2,200 MWt, the power level for which an operating license is presently sought, the cooling water temperature will be increased about 25F° (14C°) above ambient before being returned to the lake. At a maximum

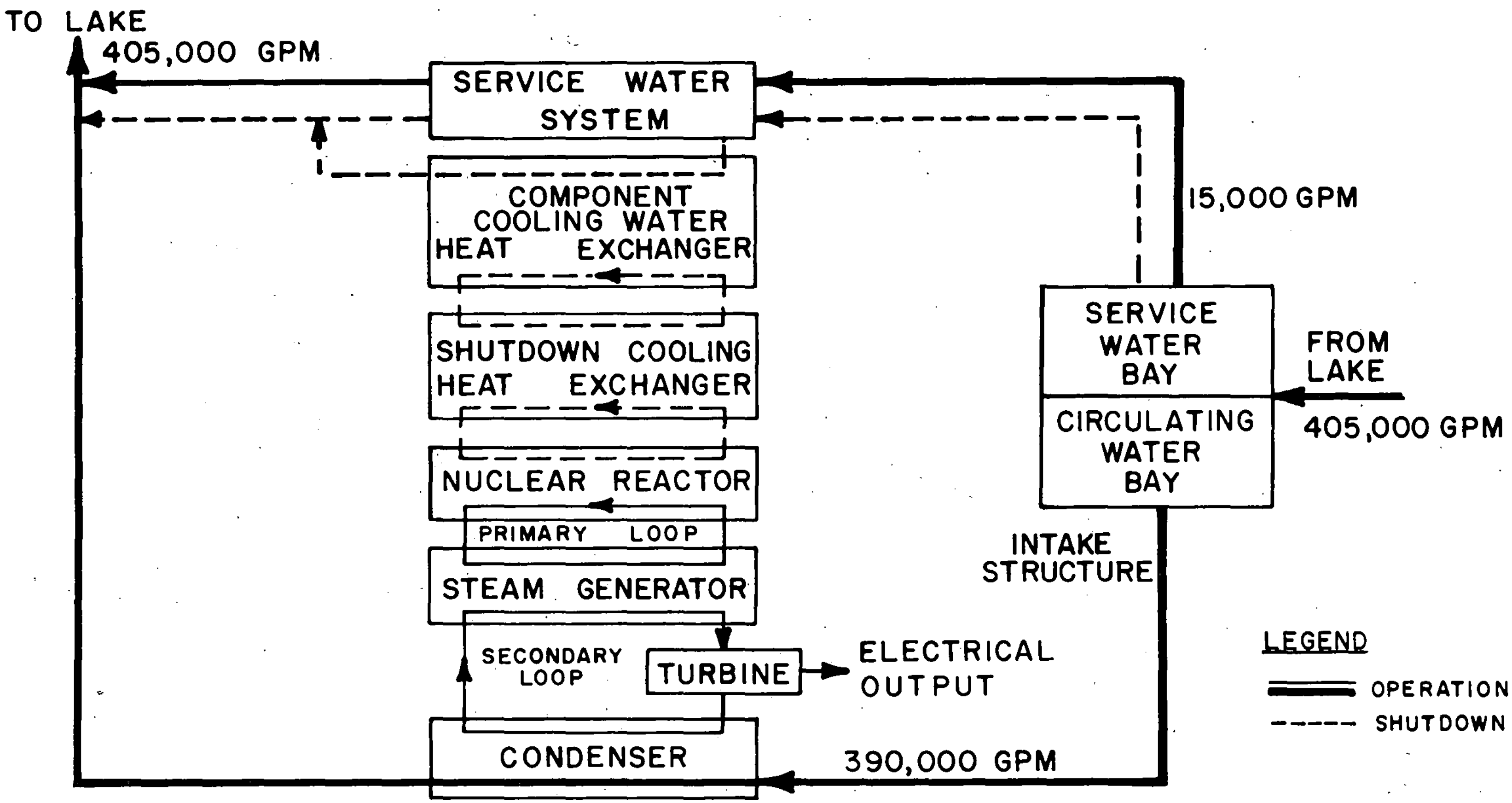


Fig. III-3
STEAM-ELECTRIC SYSTEM AND
ONCE-THROUGH HEAT DISSIPATION SYSTEM
PALISADES PLANT

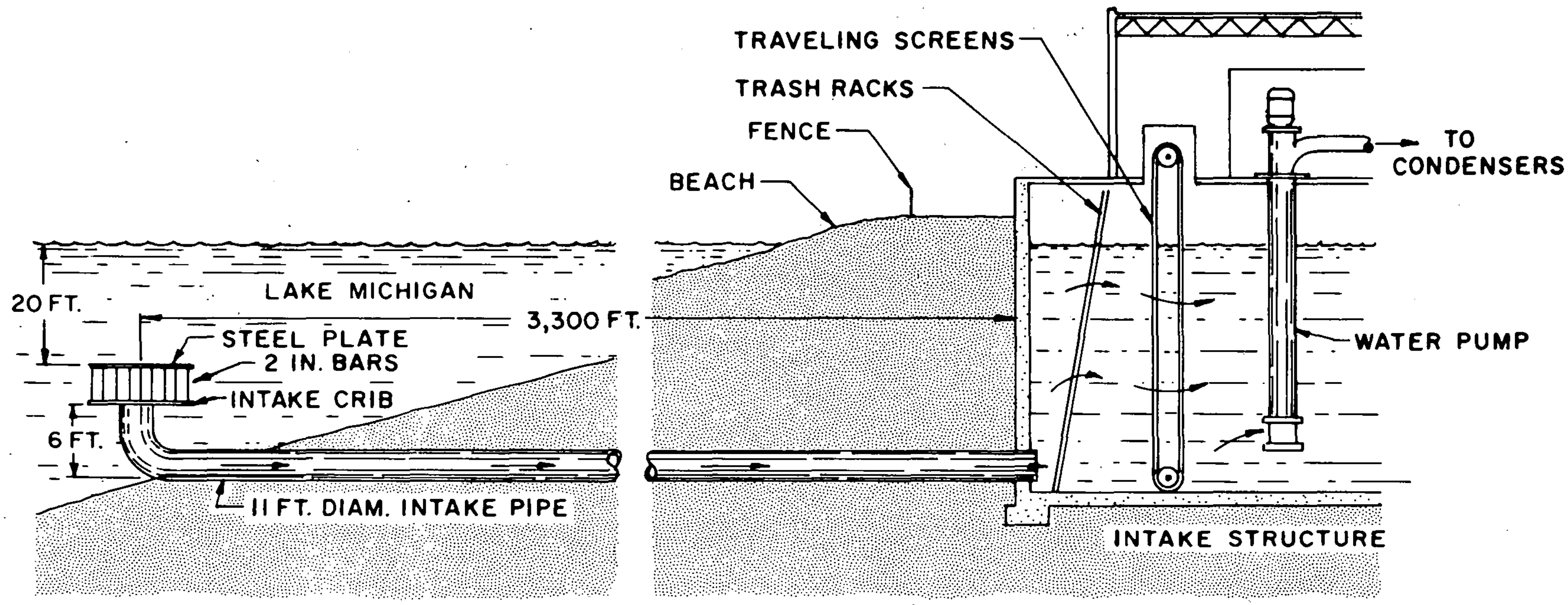


Fig. III-4
SCHEMATIC OF WATER INTAKE SYSTEM
PALISADES PLANT

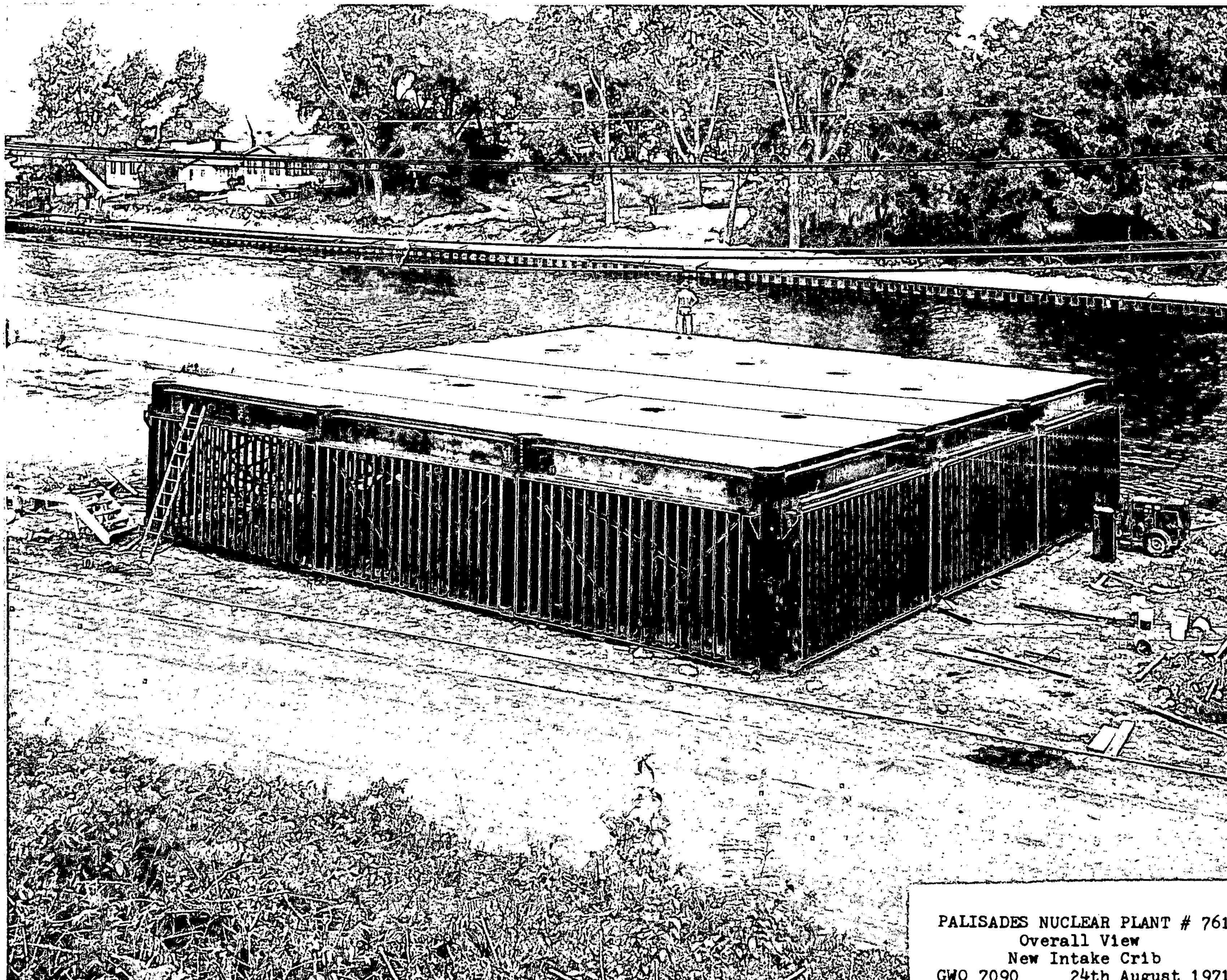
planned power level of 2,600 MWt, the temperature of the cooling water would be raised approximately 28F° (15.5C°) above ambient, provided once-through cooling system were used.

Cooling water is taken from Lake Michigan through an intake crib 20 feet below the lake's surface, 6 feet from the lake bottom, and 3,300 feet from the shoreline (Fig. III-4). The crib is a 30 feet wide by 30 feet long by 12 feet high box with a steel plate for its top and 2-inch vertical bars spaced 10 inches apart around the sides (Fig. III-5). Water flows horizontally between the vertical bars at a velocity of 0.5 to 0.6 feet per second (fps) and subsequently is diverted to an 11-foot diameter intake pipe at a velocity of 9.5 fps. The pipe transports the water to a two-bay intake structure equipped with trash racks and traveling screens (Fig. III-4). The trash racks, which serve to remove large material sucked in through the intake pipe and thereby protect the circulating water pumps, consist of a grating with vertical bars about 1-inch apart. Two 10-foot wide traveling screens with 3/8-inch openings, are installed ahead of each of the two circulating water pumps and are designed to move on a chain belt when the pressure differential reaches 10 inches of water, or about 0.4 psi. The screens are designed to keep fish and other screenable biota from entering the water circulating through the condenser. Debris collected by the trash racks is removed by a mechanical rake or scoop. The debris and small fish retained by or impinged on the traveling screens are removed by backwashing with water pumped from the intake structure and, subsequently, are collected in wire baskets and disposed of offsite as solid waste by a commercial service.

The cooling water is drawn from the circulating water bay and flows through the condenser to the discharge canal by means of two 195,000 gpm pumps. The transit time of the cooling water passage from the condenser inlet-water box to the point of discharge into Lake Michigan is approximately 25 seconds. Periodic injection of a 16% sodium hypochlorite solution into the circulating water systems prior to the water entering the condenser tubes or the service water system provides control of slime and fouling growths. (See Section III.D.3).

Cooling water for the Plant auxiliary cooling systems is pumped from the service water bay at a flow rate of approximately 15,000 gpm. The effluent from these auxiliary systems is discharged through a strainer into a common header and eventually flows into the discharge canal.

The discharge canal is a diverging pile structure on the lake shore (see Fig. III-1). It is 37 feet wide at the outlet adjacent to the



PALISADES NUCLEAR PLANT # 761
Overall View
New Intake Crib
GWO 7090 24th August 1971

Fig. III-5

building structure and diverges to a 100-foot width at the point of discharge 108 feet from the outlet. The average discharge velocity will be less than 2 fps. The discharge canal water is continuously monitored by the applicant for radioactivity, temperature changes across the condenser, and samples are collected for chemical analyses. The discharge of the cooling water is discussed in greater detail in Section III.D.1.c. A 17,000 gpm pump is provided in the discharge canal for the purpose of recirculating warm discharge water to the intake during winter months to protect against ice formation within the intake system.

During periods of reactor shutdown, heat resulting from radioactive decay of the fission products in the core and activation products in the primary coolant will be transferred through the shutdown-cooling heat exchanger to the component-cooling water system. A 13,000 gpm flow from the service water system will then transfer residual heat from the component-cooling water heat exchanger to Lake Michigan via the existing discharge structure. Normal shutdown cooling should require about 4 hours.

b. Proposed Closed-Cycle Cooling System

A modified closed-cycle condenser cooling system is proposed for long-term operation of the Plant, pursuant to the applicant's March 12, 1971, Settlement Agreement with the intervenors and described in Amendments No. 21 and No. 24 to the Final Safety Analysis Report. The installation, to be completed by November 1973, will consist of two rows of mechanical draft evaporative-type cooling towers (See Fig. II-2).

The proposed closed-cycle system will be constructed so that heated water from the condenser will flow into the cooling towers through two buried circulating water lines. The cooled water effluent from the cooling tower basin will flow by gravity to the condenser inlet system through two buried lines; from here it will be pumped through the turbine condenser at a flow rate of 390,000 gpm and returned to the cooling towers (Fig. III-6). The existing intake structure will be modified so that it will transfer water to the service water bay only; the service discharge water will provide makeup for the cooling-tower system.

It is estimated that approximately 12,320 gpm of water will be lost from the system due to evaporation and drift incurred at the cooling towers. The evaporative losses will, in turn, cause a buildup of salts and other impurities in the closed system. To control the concentration of these impurities, 1,320 gpm of water will be blown

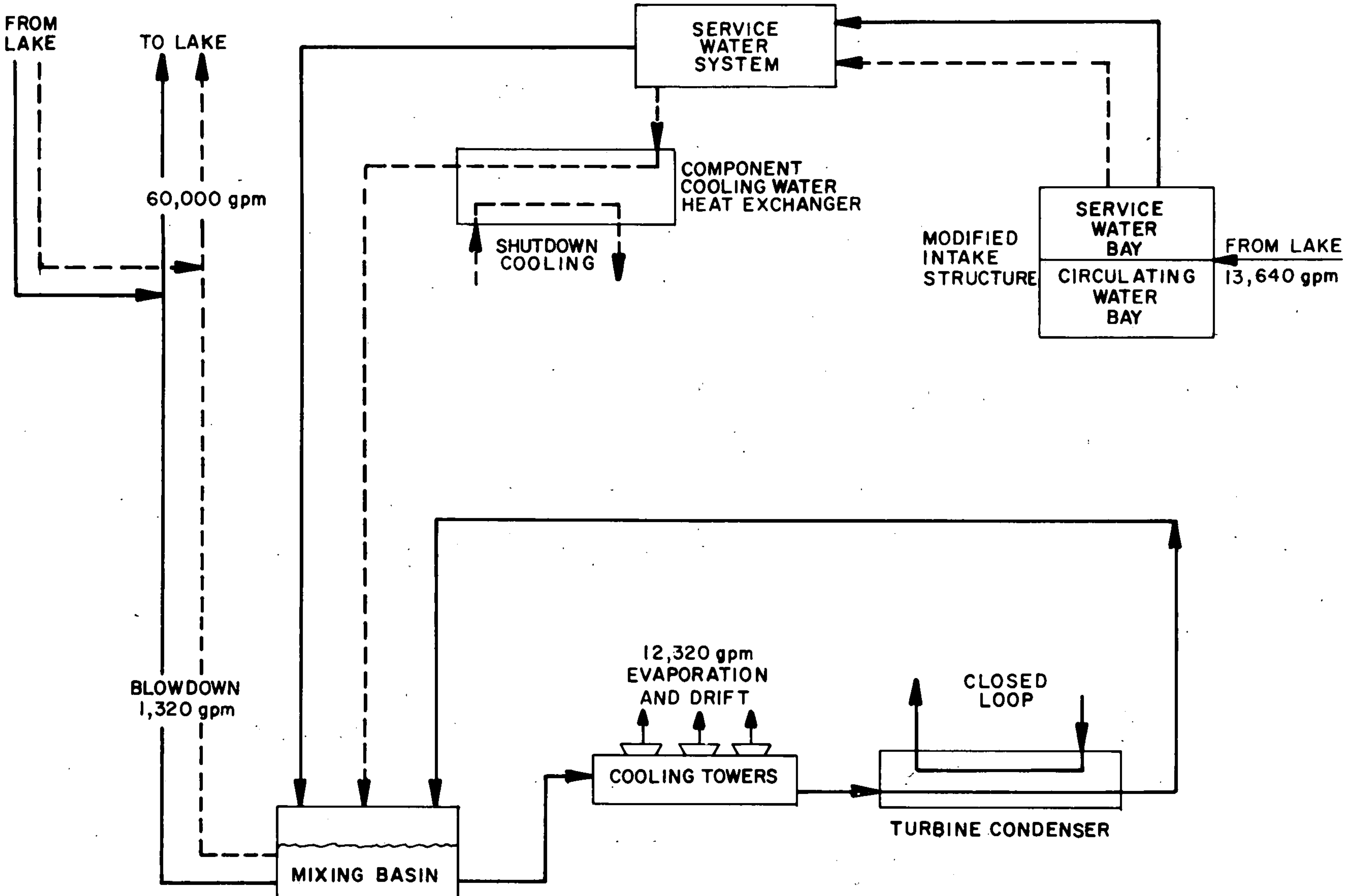


Fig. III- 6
PROPOSED CLOSED-CYCLE HEAT DISSIPATION SYSTEM
PALISADES PLANT

down (discharged) into the lake. To replace the blowdown and the evaporative and drift losses, 13,640 gpm of makeup water will be supplied, as mentioned above, by the service water system discharge.

Two 30,000 gpm pumps will be installed to add lake water to the blowdown, in order to dilute the blowdown water such that the temperature of the mixed lake water and blowdown will not exceed the ambient temperature of the lake by more than 5°F° (2.8C°). The total discharge will then enter Lake Michigan via the existing discharge structure at a flow rate of approximately 60,000 gpm and a velocity of less than 0.3 fps. During periods of cooling tower shutdown, the service water will flow to the discharge structure and overflow a weir partition into the lake. Neither the existing condenser cooling system nor the proposed cooling tower system will have any safety related functions. Schematics of the closed-cycle cooling tower system and also the shutdown cooling system for heat removal from the reactor core are given by the applicant[17].

c. Thermal Effluent Dispersion-Once-Through Cooling

The once-through cooling system of the Palisades Plant will withdraw water at the rate of approximately 405,000 gpm from Lake Michigan, heat and discharge it at 25F° (14C°) above the ambient intake temperature, into the lake. The heat discharged, approximately 4.9×10^9 British thermal units (Btu) per hour, will be dissipated into Lake Michigan and will produce a thermal plume having a shape and magnitude dependent upon prevailing lake conditions.

The Palisades Plant will use inshore water, defined as that water lying between the shoreline and the 100-foot depth contour (about 5 miles offshore), for cooling the condensers and will then discharge the warmed water into the lake about 100 feet from the shoreline at the surface. Intake temperatures will vary both daily and seasonally due to lake water mixing resulting from temperature- and wind-induced currents and thermal stratification, as discussed previously. In Figure III - 7, Curve A indicates the variation of the average inshore water temperature during one full year. The day-to-day variation of the temperature of water used in the Campbell Plant 40 miles north of Palisades is shown in Curve B of the figure.[3] From the average inshore temperature data, the temperature of the Palisades discharge at the outfall into Lake Michigan has been calculated, assuming full-power operation and once-through cooling with a temperature rise of 25F°. The results of this calculation are shown in Curve C of Fig. III - 7.

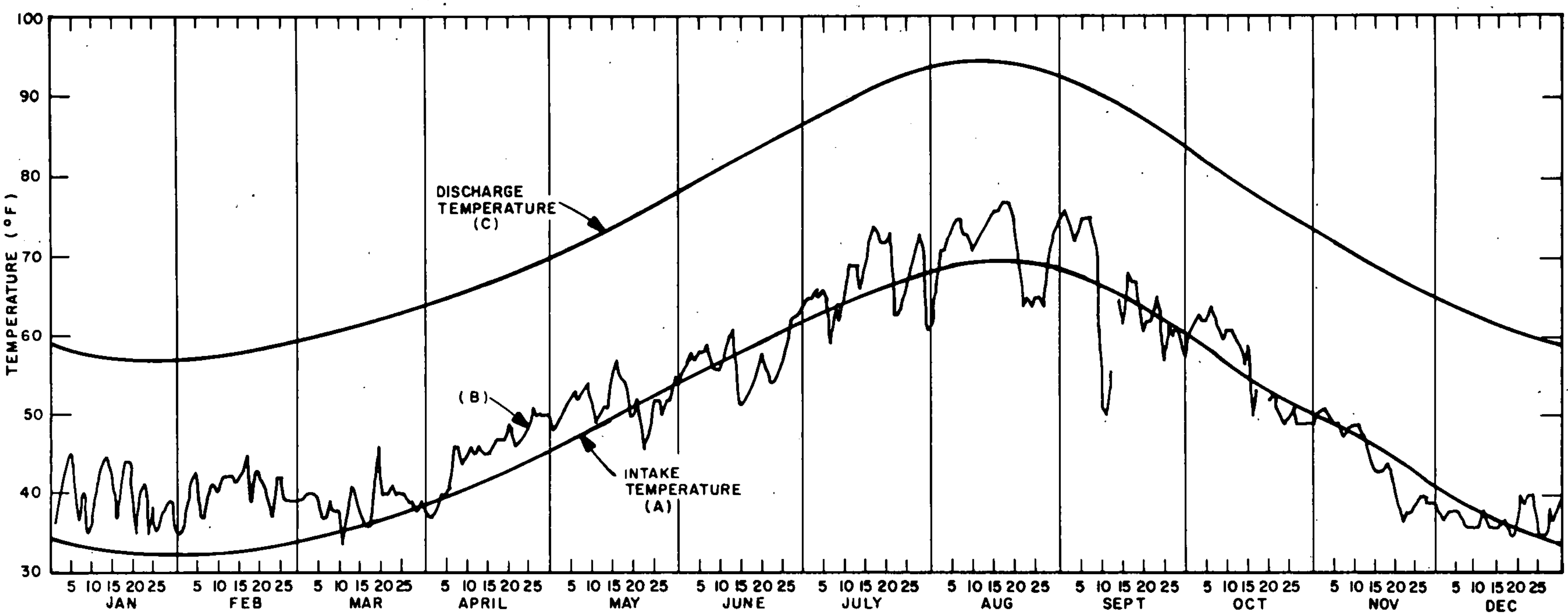


FIG. III-7

WATER TEMPERATURES AT PALISADES. (A) AVERAGE LAKE MICHIGAN WATER TEMPERATURES IN INSHORE AREAS, MEASURED ON THE BOTTOM AT 18 TO 36 FEET (4). (B) ACTUAL AVERAGE TEMPERATURES OF INTAKE WATER IN 1969 AT THE J.H. CAMPBELL PLANT AT PORT SHELDON, MICHIGAN, LOCATED APPROXIMATELY 40 MILES NORTH OF THE PALISADES PLANT (3). (C) CALCULATED AVERAGE DISCHARGE TEMPERATURE OF COOLING WATER FROM THE PALISADES PLANT WHEN OPERATING AT FULL POWER WITH A Δt OF 25 F°.

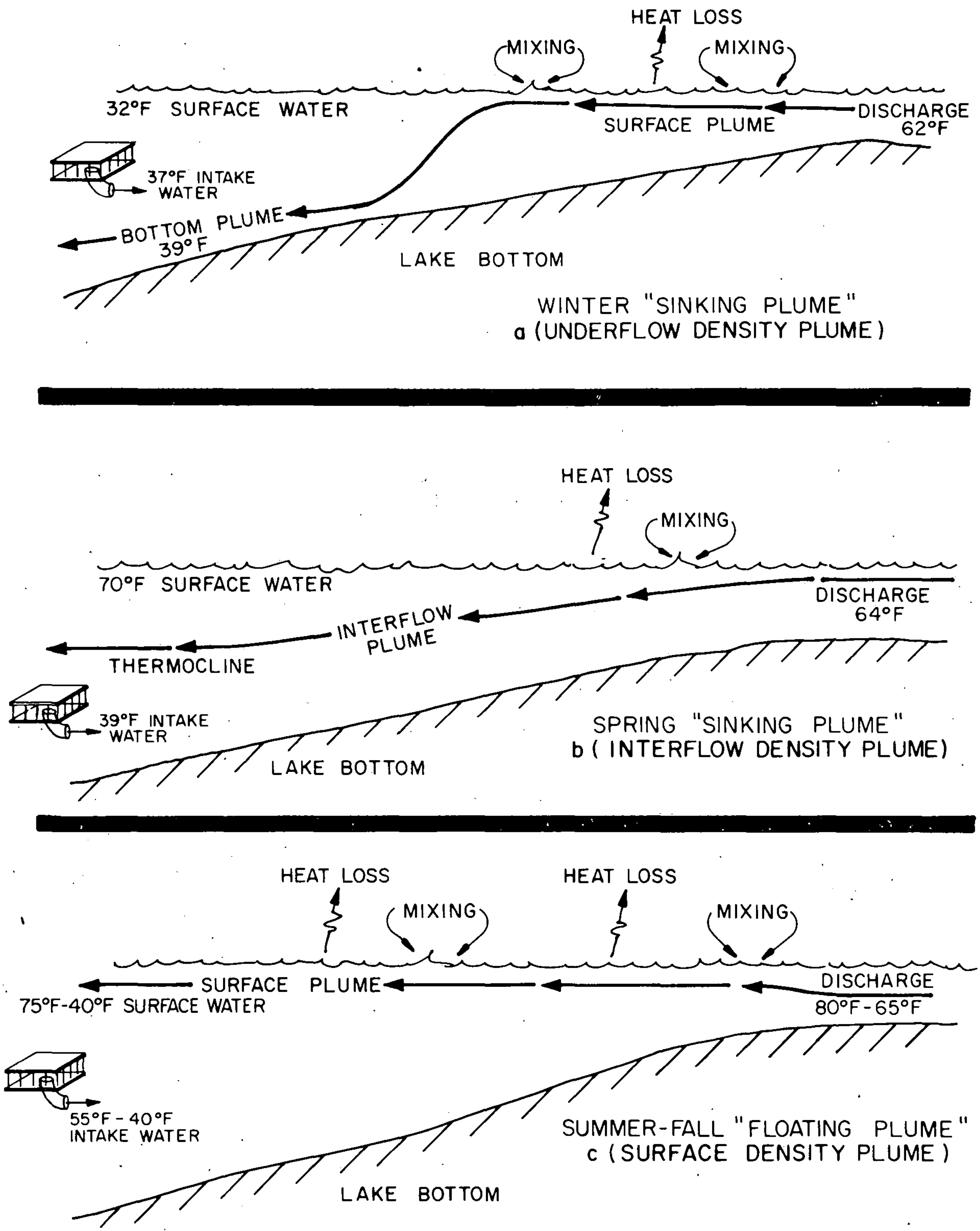


Fig. III-8
PLUME MODELS OF THE WATER DISCHARGE INTO THE INSHORE WATERS OF LAKE MICHIGAN
PALISADES PLANT

The discharged warm water from the Plant will enter Lake Michigan and form a thermal plume. Since no quantitative description of the thermal plume had been made by the applicant or other agencies, the staff conducted a study to ascertain the properties of the plume under various conditions. The results of this study were used to evaluate the applicant's qualitative estimates and to assess the environmental effects of the thermal discharge. The following paragraphs describe the staff's findings concerning the thermal plume.

(1) Qualitative Plume Description

The thermal discharge will approximate one of the three patterns of heat dissipation into the inshore water zone, depending upon the prevailing lake temperatures. Schematics of these dissipation patterns for operation of the Palisades Plant at 100% of rated power, are shown in Fig. III - 8.

During the winter, the temperature of the inshore waters will range from about 32°F (0°C) at the surface to approxmiately 37°F (2.9°C) near the bottom.[4] The cooling water, taken from this 37°F water, will then be discharged at the shoreline into the 32°F water at a temperature of approximately 62°F (17°C), and thus the warmed water will tend to dissipate over the surface of the lake near the shoreline.[5] The cold air immediately above the surface water and the mixing induced by surface turbulence will rapidly reduce the temperature of the plume. When the temperature of the plume reaches 39°F (3.9°C), the plume will be more dense than the 32°F inshore lake water at the surface and the 37°F water near the bottom and thus sink to the bottom of the lake. This phenomenon is referred to as density underflow. (Figure III - 8a.)

During the spring warming period, the surface water of the inshore water zone will be warmed to about 70°F (21°C), while the bottom waters remain below 40°F (4.5°C).[6] Plant operation during this time may result in a cooling water discharge that is cooler than the surface waters. Should this occur, the plume in which the dense 39°F water taken from the bottom of the lake is heated to approximately 64°F (18°C), will tend to sink to the thermocline. This is termed density interflow. (Fig. III - 8b). The probability of producing a density interflow thermal plume is greatest while operating at less than rated power.

For most of the year, the temperature of the cooling water intake will approximate the temperature of the surface water; the cooling water discharge will thus be much warmer than the inshore waters.

During this time the thermal plume will tend to dissipate entirely over the surface of the lake, with the shape and magnitude of the plume controlled by the prevailing lake currents. This is the summer-fall floating plume or surface density plume. (Fig. III - 8c)

Two basic current patterns are known to exist offshore of the Palisades Plant--alongshore currents produced by winds from the northwest (24% of the time and southwest (30% of the time) and negligible offshore currents resulting from no wind (6% of the time) or offshore winds from the east (40% of the time). For the offshore current case, which will exist for about 46% of the time, the thermal plume resulting from the cooling water discharge will be bell-shaped, with its center line more or less perpendicular to the lake shoreline. The alongshore currents, which will exist about 54% of the time, will tend to bend the thermal plume in the direction of the current flow. This condition will present a dispersion problem inasmuch as the plume, having only one side adjacent to dilution water, will extend a greater distance from the discharge point than for the offshore current case. Experimental data on plumes produced by strong along-shore currents indicate that the temperature of the plume will essentially be constant over the entire area between the outer edge and the shoreline.[8] The same data also indicate, for this extreme case, the plume temperature will be essentially constant from the surface to the lake bottom.

(2) Quantitative Plume Description

To quantitatively describe the behavior of the Palisades thermal plume, two independent studies were conducted-- (1) a study employing a mathematical model developed by Motz and Benedict[26] in conjunction with empirical relationships developed by Pritchard[6] and (2) a study combining empirical relationships developed by Asbury and Frigo[7] and by Pritchard[6] with experimental data collected by personnel of Argonne National Laboratory.[8]

(a) The Mathematical Model Approach

The Motz-Benedict model was used to predict the distances from the point of discharge that specific excess temperatures will exist. In predicting these distances for both the no-current case and the strong along-shore current case, the following assumptions were made:

1. The plume will dissipate entirely on the surface of the lake.

2. All flows are steady.

3. The discharge and the resulting plume are two dimensional; i.e., there is no vertical mixing. For the along-shore current case, this is probably a valid assumption in as much as the plume will extend to the bottom of the lake in the near-shore region. During periods of no lake currents, the plume will extend into the deeper waters and stratify; some vertical mixing will undoubtedly occur and the model will thus predict plumes larger than will actually exist.

4. The lake currents produce a uniform velocity field.

Other assumptions contained within the basic mechanics of the model can be found in Reference 26.

Using the distance values obtained from the Motz-Benedict model, the dimensions and corresponding areas of the plumes enclosed within specific isotherms were then calculated using empirical relationships developed by Pritchard[6]. The results of this study for the no-current case and the strong along-shore case are listed in Tables III-1 and 111-2, respectively.

(b) <u>The Empirical Relationship Approach</u>

In addition to the mathematical model study, an empirical relationship developed by Asbury and Frigo[7] was used to predict the area enclosed by a specific isotherm of a surface plume. Although this relationship does not allow for variation of parameters such as the velocity of the discharge, the velocity of the lake currents, the geometry of the discharge structure, and the bottom slope of the lake, it is based on data taken from power plant discharges that have similar discharge characteristics. For instance, all discharges are into large lakes, all are surface discharges, and all discharges have low densimetric Froude numbers. The densimetric Froude number is a dimensionless ratio of the inertial forces of the discharge to the buoyant forces of the discharge. It is represented as

$$\mathbb{F}_D = U_o \Big/ \sqrt{hg \left| \frac{\Delta\rho_o}{\rho_o} \right|} \qquad (1)$$

where $\mathbb{F}_D$ = densimetric Froude number,
U_o = velocity of the discharge,
h = depth of the discharge,
g = acceleration of gravity,
$\Delta\rho_o$ = difference in density between the heated discharge and the receiving water,
ρ_o = density of the discharge

TABLE III-1

Thermal Plumes from the Palisades Plant Operated at Different Power Levels Using the Once-Through Cooling System as Predicted by the Analytical Model (No-Current Case).

A. At 440 MWt (20% of rated power) Δt = 7F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
5	0.1	0.8
3	0.2	5.5
1	1.2	226

B. At 1,320 MWt (60% of rated power) Δt = 16F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
12	0.1	1.1
8	0.2	5.5
5	0.4	18
3	0.8	95
1	2.5	880

C. At 2,200 MWt (100% rated power) Δt = 25F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
20	0.1	1.0
10	0.3	12.3
5	0.7	68
3	1.4	260
1	2.6	930

*Conversion factor is 2.23×10^{-5} acre/sq. ft.

TABLE III-2

Thermal Plumes from the Palisades Plant Operated at Different Power Levels Using the Once-Through Cooling System as Predicted by the Analytical Model (Strong Along-Shore-Current Case).

A. At 550 MWt (20% of rated power) $\Delta t = 7F^\circ$ at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
5	0.26	9.2
3	0.55	40
1	3.4	247

B. At 1,320 MWt (60% of rated power) $\Delta t = 16F^\circ$ at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
12	0.1	1.1
8	0.4	32
5	1.1	80
3	2.5	180
1	7.9	578

C. At 2,200 MWt (100% of rated power) $\Delta t = 25F^\circ$ at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
20	0.1	1.8
10	0.6	57
5	2.3	168
3	4.0	294
1	10.8	782

Low values of this number (1-10) indicate that the discharge will tend to be bouyant and therefore limit the mixing with the receiving water body and thus larger plumes will result. Higher values indicate better mixing and smaller plumes. In comparison, the surface discharge into Lake Michigan from the Palisades Plant will, during operation at full power, have a densimetric Froude number of approximately 2.8. Since the densimetric Froude numbers of the discharges incorporated in the Asbury-Frigo relationship are slightly smaller than this (2.5 and less), it is concluded that utilization of this relationship for predicting plume areas for the Palisades Plant probably resulted in values which are larger than should actually occur. Therefore, the staff believes that the Asbury-Frigo relationship is valid for predicting the upper-limit values of thermal plume areas for the Palisades Plant.

Using the plume areas determined by the Asbury-Frigo relationship, the corresponding dimensions of the no-current thermal plumes were determined from empirical relationships developed by Pritchard[6]. The dimensions of the plumes resulting from the strong along-shore currents were approximated using experimental data taken from the Point Beach Plant[8]. Since this plant has discharge characteristics similar to the Palisades Plant (a rectangular, surface discharge into Lake Michigan with a flow rate of 790 cfs or 355,000 gpm and an excess temperature of approximately 20°F), this method of predicting plume width should produce a reasonable approximation. The axial length of and the area enclosed by several different isotherms are listed for both the no-current case and the strong along-shore-current case in Tables III-3 and III-4, respectively.

Another important thermal effluent characteristic determined from this study was the exposure time for the no-current case. (The exposure time is defined as the time required for water to travel from the condensers through a specific isotherm of the thermal plume.) These times, which were determined using analytical procedures developed by Pritchard[6], are shown graphically in Fig. III-9.

(c) Comparison of Studies

As seen from comparing Tables III-1 and III-2 with Tables III-3 and III-4, the Motz-Benedict model predicted somewhat smaller plumes than did the empirical relationship of Asbury and Frigo. Since the analytical model incorporated more discharge parameters than did the empirical relationship, it is probable that the analytically determined plumes more closely approximate the plumes that will actually occur than do the empirically determined plumes. To insure that the worst possible case was assessed, however, the empirically determined plumes shown in Figs. III-10 and III-11 were employed in formulating conclusions presented in later sections of this Statement.

TABLE III-3

Thermal Plumes from the Palisades Plant Operated at Different Power Levels Using the Once-Through Cooling System as Predicted by Empirical Relationships. (No-Current Case)

A. At 440 MWt (20% of rated power) Δt = 7F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
5	0.2	7.4
3	0.4	123
1	1.5	310

B. At 1,320 MWt (60% of rated power) Δ 16F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
12	0.2	3.7
8	0.5	31
5	0.9	114
3	1.2	192
1	2.3	724

C. At 2,200 MWt (100% of rated power) Δt = 25F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres*
20	0.1	2.5
10	0.5	39.3
5	1.1	165
3	1.6	372
1	2.5	889

*Conversion factor is 2.23×10^{-5} acre/sq. ft.

TABLE III-4

Thermal Plumes from the Palisades Plant Operated at Different Power Levels Using the Once-Through Cooling System as Predicted by Empirical Relationships (Strong Along-Shore Current Case).

A. At 440 MWt (20% of rated power) Δt = 7F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
5	0.2	7.4
3	0.5	123
1	4.3	310

B. At 1,320 MWt (60% of rated power) Δt = 16F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
12	0.2	3.7
8	0.5	31
5	1.6	114
3	2.6	192
1	9.9	724

C. At 2,200 MWt (100% of rated power) Δt = 25F° at outfall.

Temp. of Isotherm, F° Above Ambient	Axial Length of Plume Miles	Area Enclosed by Isotherm, Acres
20	0.1	2.5
10	0.5	39
5	2	165
3	5.1	372
1	12	889

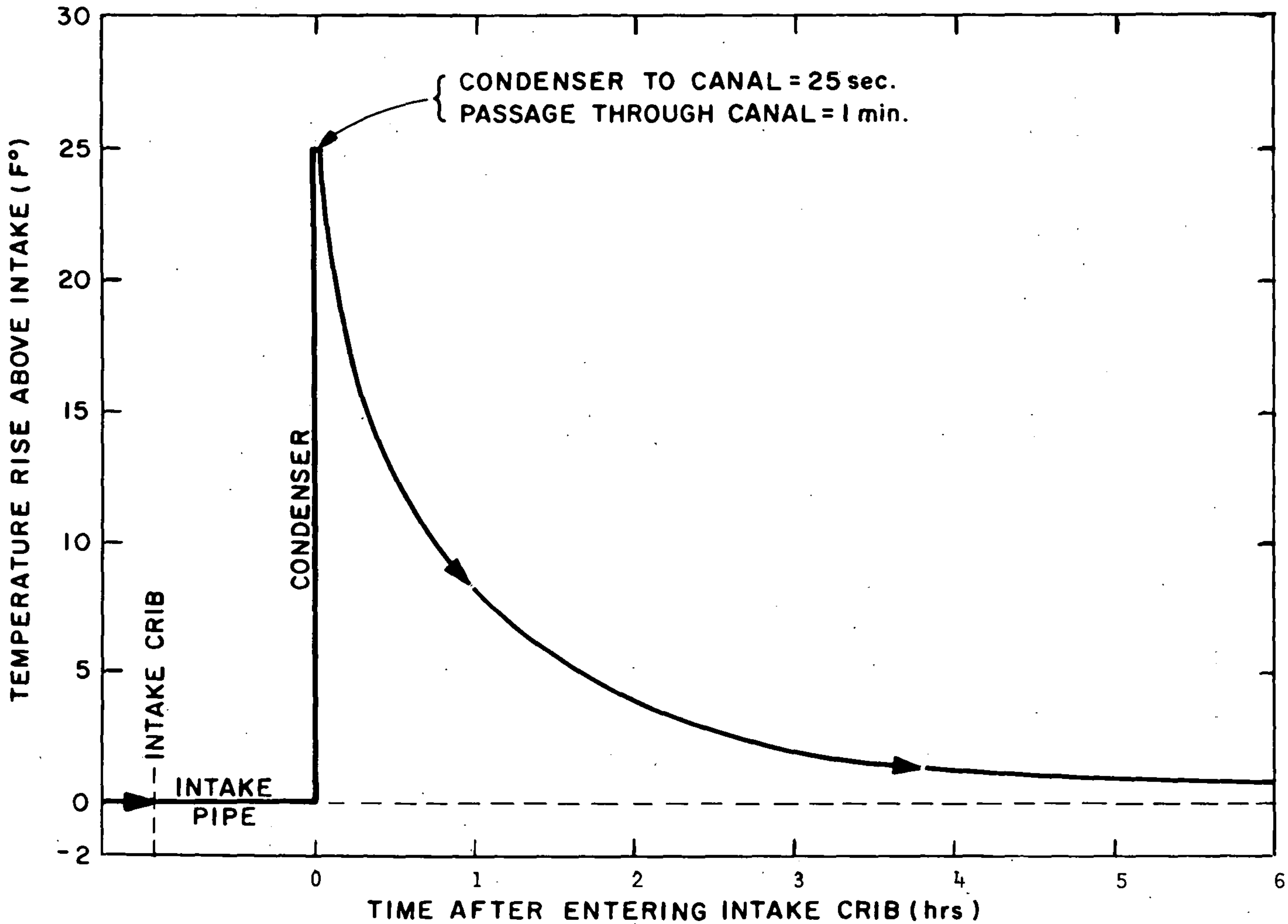


Fig. III- 9

TIME-COURSE (LEFT TO RIGHT) OF TEMPERATURE CHANGE IN PALISADES ONCE-THROUGH COOLING WATER (ESTIMATED FROM REFERENCES CITED IN TEXT). NO-CURRENT CASE.

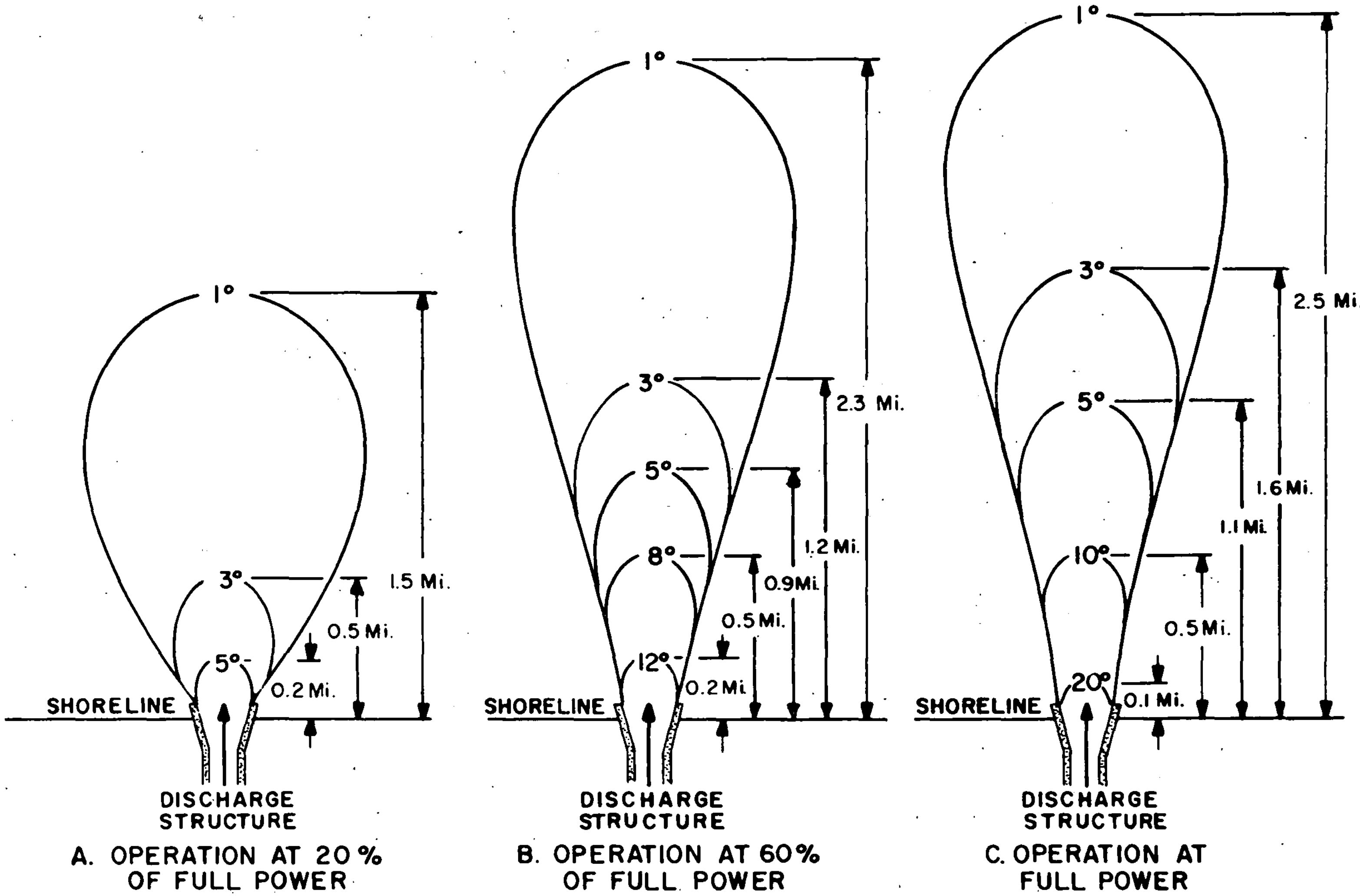
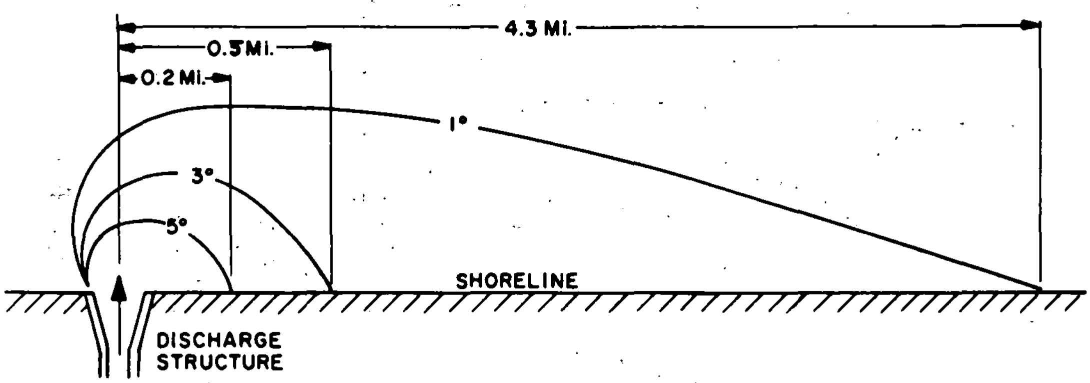
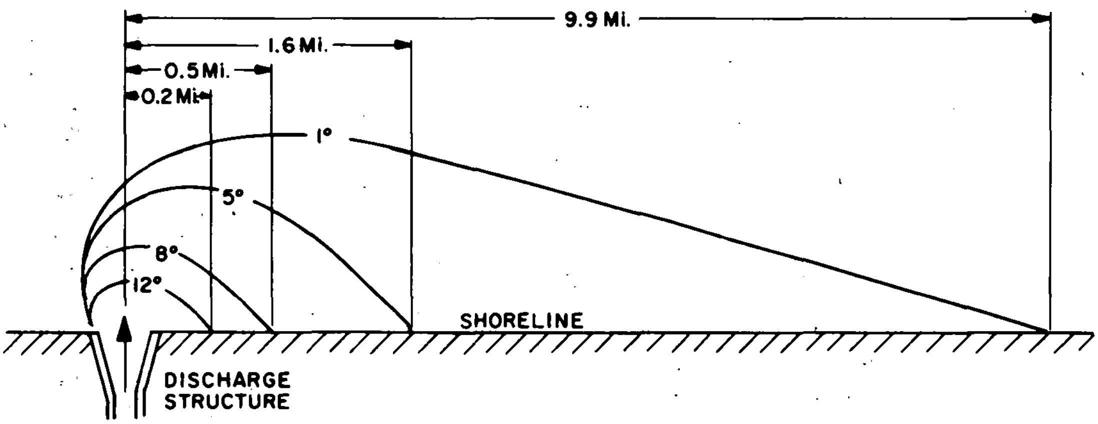


Fig. III - 10

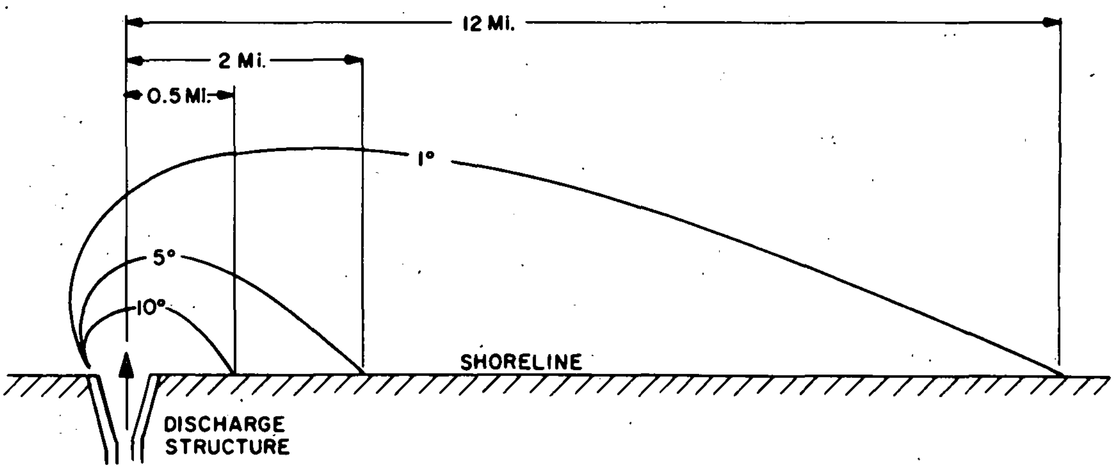
PREDICTED THERMAL PLUMES FOR PALISADES PLANT
ONCE-THROUGH COOLING SYSTEM
SURFACE PLUME DISSIPATION
NO-CURRENT CASE



A. OPERATION AT 20% OF FULL POWER



B. OPERATION AT 60% OF FULL POWER



C. OPERATION AT FULL POWER

Fig. III - 11

PREDICTED THERMAL PLUMES FOR PALISADES PLANT
ONCE-THROUGH COOLING SYSTEM
SURFACE PLUME DISSIPATION
STRONG-ALONG-SHORE CURRENT CASE

As is apparent from the foregoing discussions, neither of the plume analyses employed by the staff attempted to predict the vertical temperature distributions of the Palisades plumes. Although preliminary attempts have been made to develop models that do predict vertical temperature distributions resulting from surface discharges, the staff believes that the technology has not yet progressed to the point of accuracy doing so, especially in the presence of ambient lake currents.

The Environmental Protection Agency, in its comments concerning the Draft Detailed Statement for the Palisades Plant in Appendix XII-5, expressed concern over the effects of the so-called "thermal bar" of Lake Michigan on the dissipation of heat and chemicals from the Palisades effluent. As explained in Section II.E.2 of this Statement, the physics of this phenomenon dictate that mixing across the thermal bar must occur and thus dissipation of the Palisades effluent should not be inhibited. The results of the multispectral survey of power plant thermal effluents in Lake Michigan[27] indicate that no direct water mass relationship exists between any of the three plant discharges studied and changes in the thermal bar or currents in Lake Michigan. The multispectral processing showed no evidence of any water masses that could be attributed to the effect of warm water discharges from power plants into the lake. Warm water from rivers which also carry sediments, pollutants, and runoff nutrients showed distinctive water mass distributions. Especially significant were the results obtained during the period of the thermal bar formation at the Campbell Plant site. Since the bar itself has already been shown in previous studies to contain a higher algae content on the warmer scale, the lack of distinctive color in the discharge plume suggests that a color associated with high algae content is not present in the Campbell plume. The Michigan Water Resources Commission also comments in Appendix XII-9 that during winter "the thermal plume will develop a density underflow within the thermal bar of the onshore zone." This would result in a sinking plume, which was recently observed by the applicant, and could cause the plume to come in contact with the maximum density water lying in the bottom zone of the main body of the lake. "This may in effect disrupt the thermal bar phenonemon resulting in a significant increase in the onshore temperature regimen." The Water Resources Commission recommends additional emphasis placed on investigating the magnitude of the discharge plume. The staff has recommended to the applicant to carry out a thermal plume study in order to develop a model for predicting sizes, shapes and locations of thermal plumes. This effort is underway as a part of the applicant's environmental surveillance program required by the Technical Specifications.

On November 19, 1971, The Michigan Water Resources Commission established a thermal discharge standard (Paragraph A6) as an Amendment to the Order of Determination No. 931 (Order No. 1582) applicable for the Palisades Plant.[10] This standard is that the thermal discharges are not to increase the natural temperature of the lake at the edge of a mixing zone, which shall not exceed an area equal to the area of a circle 3,630 feet in radius, by more than 3 F°, or to result in a maximum monthly temperature, at the edge of the mixing zone, higher than those listed below:

Month	Temp °F*	Month	Temp °F*
January	45	July	80
February	45	August	80
March	45	September	80
April	55	October	65
May	60	November	60
June	70	December	50

Since the area of a circle 3,630-ft in radius is approximately equal to the area of a semicircle 1-mile in radius, the mixing zone is equivalent to a semicircle of 1-mile radius, centered at the discharge point, and with its diameter along the shoreline.

The maximum area of the mixing zone as described in the Michigan Water Resources Commission's thermal discharge standard is the area of a circle with a radius of 3,630 feet. This is 41,400,000 square feet or 950 acres. Table III-5 lists the estimated areas of the 3 F° isotherms for the thermal plumes developed during partial and full power operation of the Palisades Plant. It is apparent that the staff calculations show the area enclosed by the 3 F° isotherms of the thermal discharges at 20%, 60% and 100% of full power operation of the Palisades Plant will be well within the Michigan thermal discharge standard established for this Plant. The Order of Determination for the Plant also has a condition (Paragraph A7) that "7. Not impart heat or contain any substances in OR OUTSIDE OF THE MIXING ZONE IN sufficient quantity to create conditions which are or may become injurious to the public health, safety or welfare; or which are or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which are or may become injurious to the value or utility of riparian lands; or which are or may become injurious to livestock, wild animals, birds, fish or aquatic life or the growth or propagation thereof."

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*The temperature is to be measured in the upper one meter of the lake surface. The Order also states, "...the temperature limits set forth in Paragraph 6A of this Order shall be reviewed as to the adequacy and suitability by the Commission on or before November 1, 1973."

TABLE III-5

Area of 3 F° Isotherm for Once-Through Cooling System
(Empirical Relationship)

Percent of Power %	Wt at Outfall F°	Area of 3 F° Isotherm sq. ft.	acres
20	7	1.8×10^6	123
60	16	8×10^6	192
100	25	16×10^6	372

The Michigan Water Resources Commission's water quality standards for Lake Michigan, as submitted in September 1971, are presently being reviewed by EPA. The proposed Lake Michigan Thermal Discharge Regulations presented by EPA[11] at the Lake Michigan Enforcement Conference, Chicago, Illinois, on March 23 and 24, 1971,* required for all waste heat discharges into Lake Michigan, that "at any time, and at a maximum distance of 1,000 feet from a fixed point adjacent to the discharge, the receiving water temperature shall not be more than 3°F above the existing natural temperature nor shall the maximum temperature exceed those listed below whichever is lower." The list of maximum monthly temperatures referred to is the same as that given by the Michigan Water Resources Commission. Thus, it should be noted that the 3F° excess isotherm of the thermal discharges from the present Palisades once-through cooling system into the lake will not satisfy the proposed EPA standards at power levels of 20% and above. However, from this conference, it was recommended that "plants not in operation as of March 1, 1971, (will)

* The recommendations of the Conference have been endorsed by the Environmental Protection Agency (ltr fm W. D. Ruckelshaus, Administrator of EPA, to W. L. Blaser, Director of Illinois Environmental Protection Agency, dated May 14, 1971) and represent the current position of EPA with regard to thermal discharges in Lake Michigan (ltr fm F. T. Mayo, Regional Administrator, Region V of EPA to W. B. McCool, Secretary, Atomic Energy Commission, dtd December 29, 1971, concerning Point Beach Nuclear Power Plant Unit #2 - Docket 50-301).

be allowed to go into operation provided they are committed to a closed-cycle cooling system construction schedule approved by the state regulatory agency and EPA. In all cases, construction of closed-cycle systems and associated intake and discharge facilities shall be completed by December 31, 1974, for facilities utilizing natural draft towers and December 31, 1973 for all other types of closed systems."[11,12] Details on these regulations are presented in an enclosure to the letter from EPA commenting on the Palisades Plant in Appendix XII-5.

All discharges, including thermal, chemical, and other discharges will be subject to the provisions of section 21(b) of the Federal Water Pollution Control Act, as amended by the Water Quality Improvement Act of 1970, and also to the limitations established by the Michigan Water Resources Commission. The applicant, on March 31, 1971, requested the State of Michigan Water Resources Commission to certify the application on discharges from the Palisades Plant in accordance with Section 21(b) of the Water Quality Improvement Act. However, the Water Resources Commission has not certified the company's application for discharge permits nor has the concurrence of the EPA been obtained. The State of Michigan will not certify the application until it is approved by EPA.

Furthermore, in a letter to the Atomic Energy Commission dated November 9, 1971,[13] the Army Corps of Engineers reported that the applicant had submitted on October 15, 1971, a revised application for a permit, under Section 13 of The Rivers and Harbors Act of 1899, to discharge approximately 544 million gallons of circulating water per day from the Palisades Plant. The applicant's application, as completed to date, for a permit to discharge effluents into navigable waters of the United States, was also forwarded on October 21, 1971, to EPA for their review and certification. The application for the Section 13 permit is still under review as of the date of publication of this Statement.

d. Thermal Effluent Dispersion - Proposed Closed-Cycle Cooling System

The proposed cooling tower system will discharge approximately 60,000 gpm of diluted blowdown water at a temperature not to exceed 5 F°* above the ambient lake temperature. This dissipation of 1.5×10^8 Btu/hr into Lake Michigan will produce a thermal plume similar to that produced by the once-through cooling system but of lesser magnitude. Using the Asbury-Frigo relationship, it is predicted that the cooling tower system will create a thermal plume

* With 60,000 gpm dilution, the diluted blowdown temperature is expected to be less than 1 F° above ambient.

having a 1 F° excess isotherm that covers an area of approximately 24 acres and a distance of 0.42 miles for the no-current case. For the along-shore current case this 1 F° excess isotherm, approximately 100 feet wide, would extend about 2 miles along the shore from the discharge point.

Schematic diagrams of thermal plumes from the once-through and the closed-cycle cooling systems are shown in Fig. III-12. Table III-6 shows the isotherms of the thermal plume from the cooling tower operation, the distance in miles the thermal plume travels from the outfall, the area in acres enclosed by the isotherms for the no-current case and the strong along-shore current case. The area enclosed by the 3 F° isotherm of the thermal plume is within the proposed EPA thermal discharge standards for Lake Michigan as well as within those of the Michigan Water Resources Commission. The EPA commented in Appendix XII-5 that it "concurs with the addition of a mechanical draft closed cycle cooling system by December 31, 1973, and will accept the interim use of the once-through system."

TABLE III-6

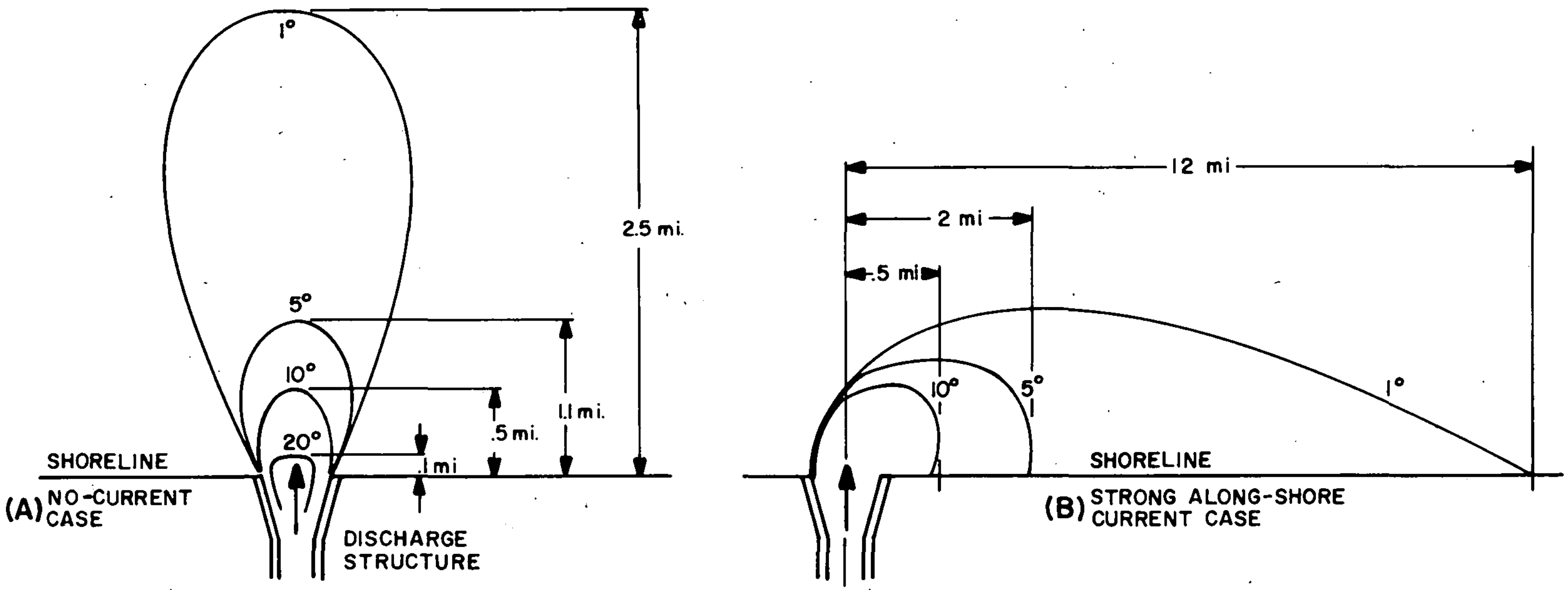
Thermal Plumes from the Palisades Plant Operated at Full Power Using a Closed-Cycle System with a Δt = 5 F° at the Outfall into Lake Michigan

A. No Current Case

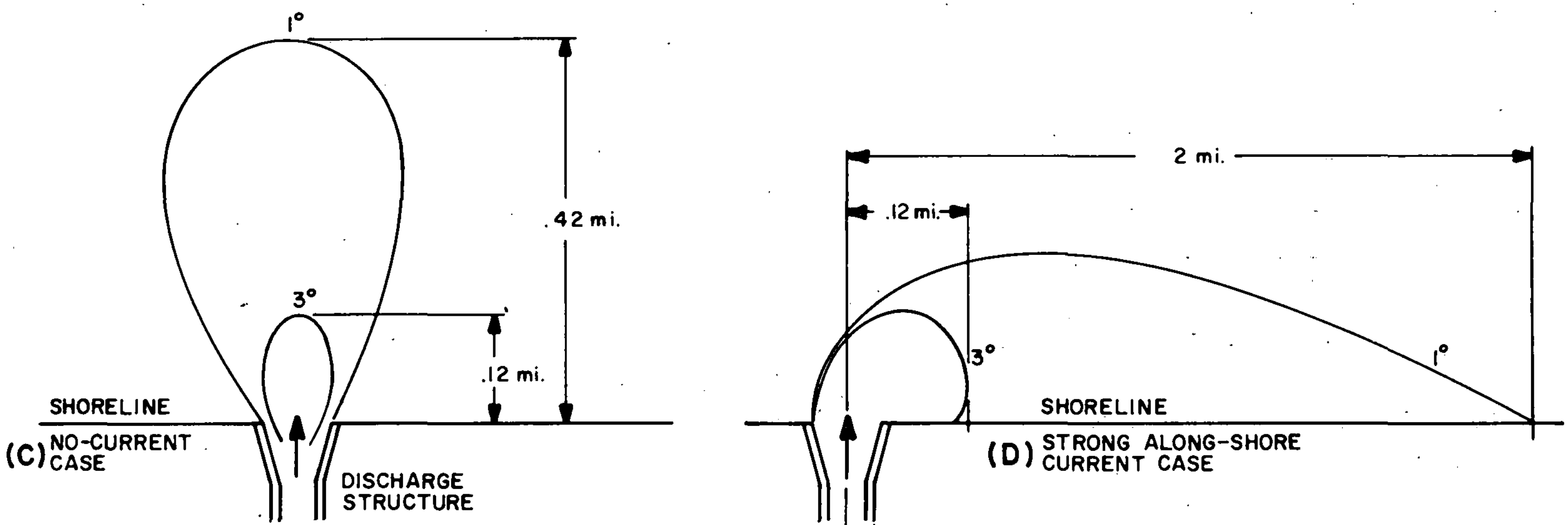
Temp. F° Above Ambient	Distance Miles	Area Acres
3	0.12	1.8
1	0.42	24.5

B. Strong Along-Shore Current Case

Temp. F° Above Ambient	Distance Miles	Area Acres
3	0.12	1.8
1	2.0	24.5



THERMAL PLUME PRODUCED BY ONCE-THROUGH COOLING SYSTEM AT PALISADES



THERMAL PLUME PRODUCED BY THE PROPOSED COOLING TOWER SYSTEM AT PALISADES

Fig. III- 12

2. Radioactive Waste

The operation of a nuclear reactor results in the production of radioactive fission products, the bulk of which remain within the cladding of the fuel rods. During operation of the reactor, small amounts of fission products may escape from the fuel cladding into the primary coolant; also, some radioactive materials are produced as a result of neutron activation of corrosion products in the coolant. Some of these materials in low concentrations may be released into the atmosphere as gases or into Lake Michigan as liquids by carefully controlled processes after appropriate treatment, monitoring, and sampling.

The radioactive waste treatment systems presently incorporated in the Palisades Plant are described in detail including proposed modifications in the applicant's Environmental Report dated October 9, 1970,[14] and in Amendment 21 to the FSAR dated March 1, 1971.[15] Diagram of the liquid radwaste system is shown in Fig. III-13 and that for the gaseous effluent system in Fig. III-14.

The quantity of radioactivity that may be released to the environment during operation of the Palisades Plant 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.

a. Gaseous Waste

During normal operation of the Plant at full power, radioactive materials released to the atmosphere in gaseous effluents include low concentrations of fission product noble gases (krypton and xenon), halogens (mostly iodines), tritium contained in water vapor and particulate material including both fission products and activated corrosion products.

The primary source of gaseous radioactive waste is from the degassing of the reactor coolant. This is principally from the exhaust of cover gases, from the waste holdup tanks and from equipment vents. Additional sources of gaseous waste activity include the auxiliary building exhaust, the vent from the steam generator blowdown tank, the turbine building exhaust, the reactor building containment air and the condenser air ejectors.

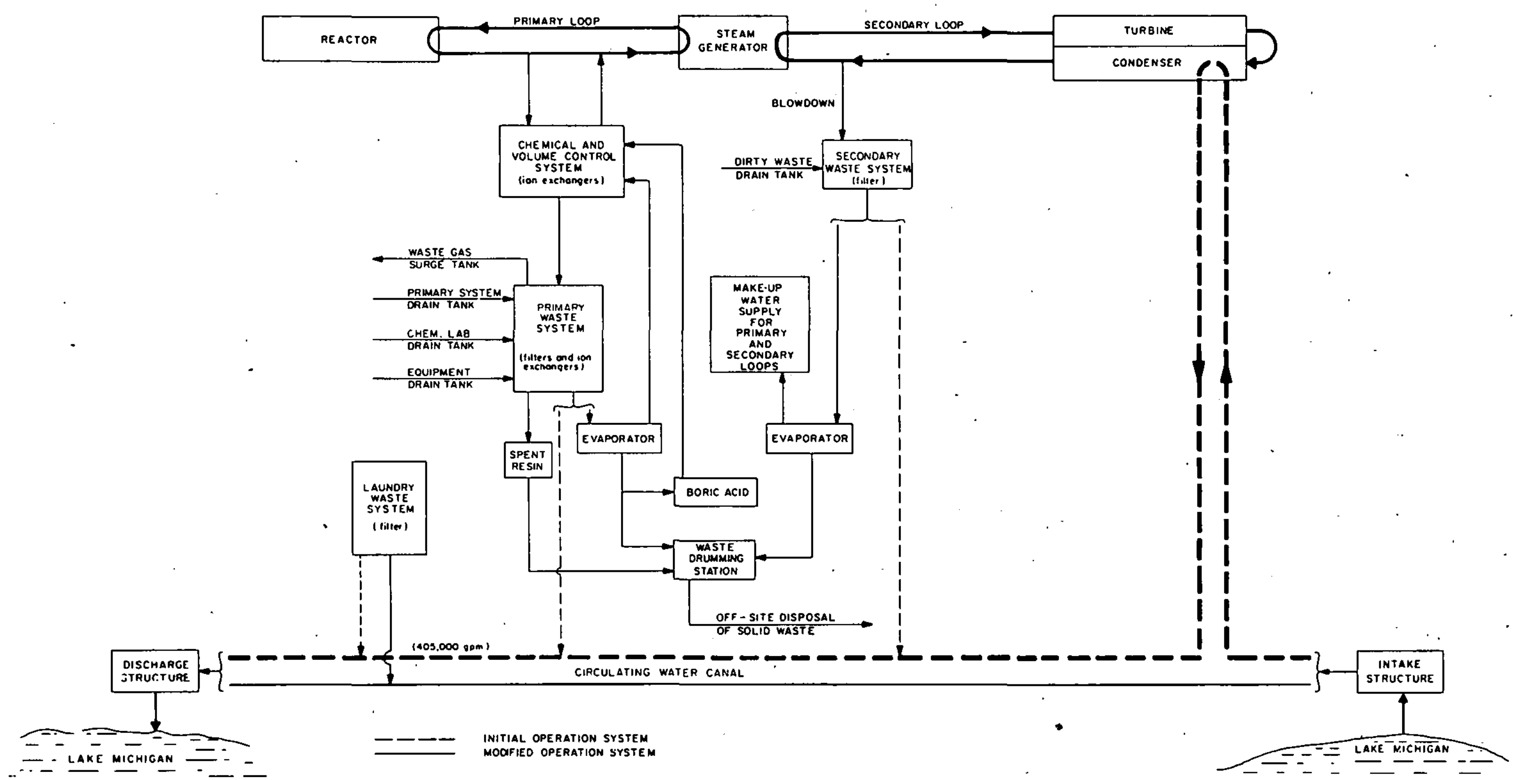


FIG. III-13. Liquid Discharge System. Palisades Plant

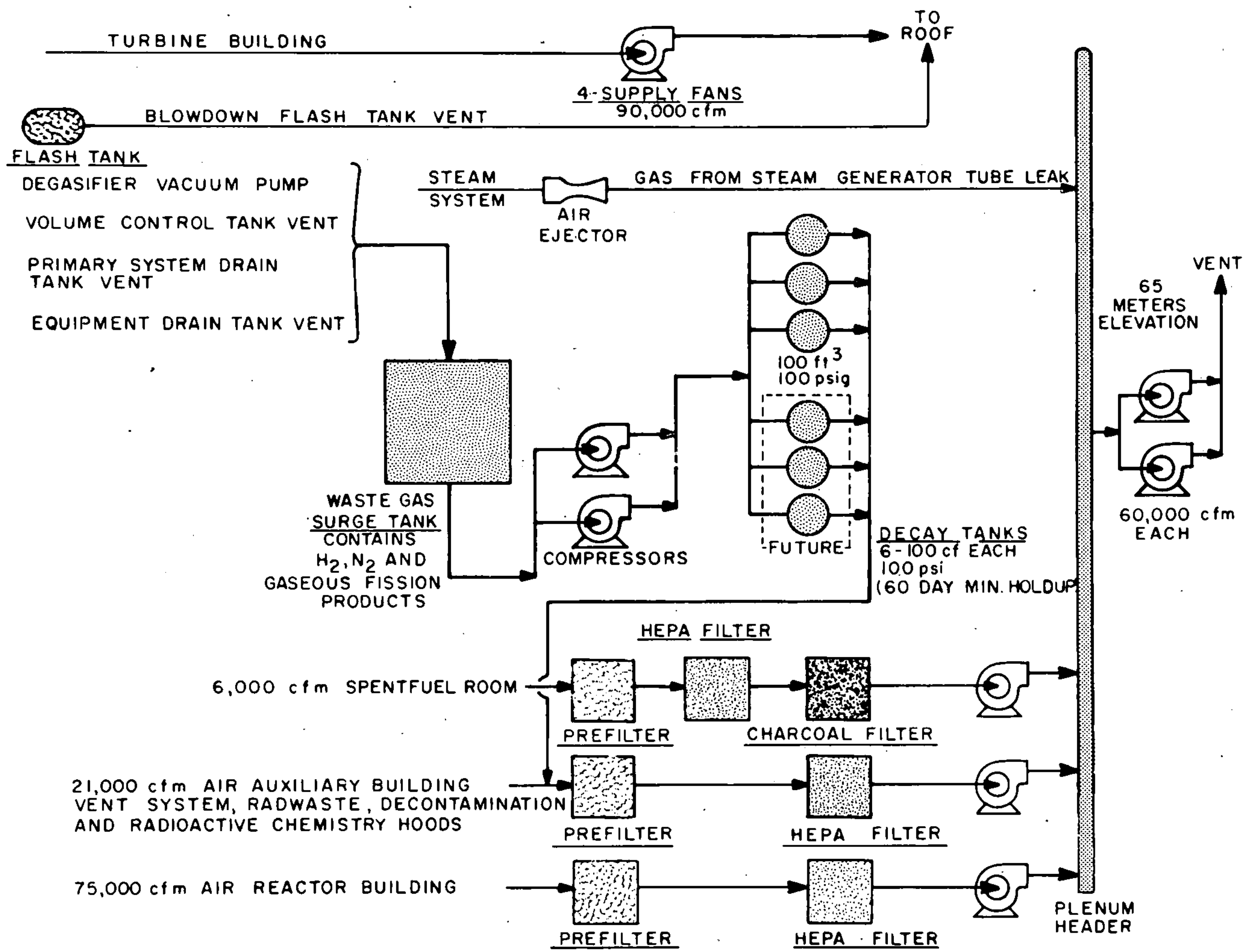


Fig. III-14
Gaseous Effluent Flowsheet
Palisades Plant

The principal sources of gaseous radioiodine released from the Plant are from the effluents of the steam generator blowdown flash tank vent, the condenser air ejector, and the exhaust air from the reactor building. Only the latter is treated by particulate filtration. No iodine removal by charcoal adsorption is provided in any of these systems. The staff has reevaluated the source term for iodine-131 and has found it to be 0.79 Ci/yr for a 60-day holdup and 0.79 Ci/yr for a 30-day holdup corresponding to the Technical Specification limit of 0.79 Ci/yr. The corresponding change made for iodine-133 is from 0.81 to 0.34 because of the staff's recalculation of the source term. The calculation of the quantities expected to be released from normal operation of the Plant assumes an average fuel cladding failure of 0.25%, combined with average experienced primary coolant leakage rates in the reactor building and between the primary and secondary system into the steam generator.

The gaseous waste system consists of a collection header which collects low-activity gas from liquids which have been previously degassed and/or vented and the gas processing section which collects gases from potentially high activity sources. The low activity gaseous wastes, which result primarily from the venting of the liquid radwaste drain collection and monitoring tanks, are discharged through high-efficiency particulate air (HEPA) filters, diluted with ventilation exhaust air and released to the atmosphere through the main stack.

Potentially high activity wastes such as gases stripped from the recycled reactor coolant together with cover gases from the demineralizers, cooling surge tank vent, primary system drain vent, volume control tank vent and the vacuum degasifier vent are collected in the waste gas surge tank. The gases are then compressed and stored in one of three gas-decay tanks or discharged directly through HEPA filters to the 200-foot high stack, which is located on the side of the containment building. High-activity gases will normally be delayed prior to being released to permit the decay of radioactive noble gases with the exception of long-lived krypton-85. Table III-7 shows the anticipated annual releases of radioactive material in gaseous effluent based on the present gas processing system and the modified system as proposed by the applicant.

TABLE III-7

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN
GASEOUS EFFLUENT FROM THE PALISADES PLANT

Nuclide	Auxiliary Building Ci/yr	Containment Purge Ci/yr	Gas Processing System (60-day holdup)* Ci/yr	Steam Generator Leakage Ci/yr	Total Ci/yr	Total** (30-day holdup) Ci/yr
K-85	6	13	620	2	640	650
K-87	3	-	-	3	6	6
K-88	8	-	-	9	17	17
Ke-131m	5	10	21	3	39	83
Xe-133	770	1,000	40	680	2,490	3,400
Xe-135	14	-	-	3	17	19
Xe-138	2	-	-	2	4	4
I-131	0.05	0.26	-	0.48	0.79	0.79
I-133	0.07	0.036	-	0.23	0.34	0.34
Total					3,214	4,180

* Design basis holdup for the Gas Processing System following installation of the modified gaseous waste system.

**Design basis for present Gas Processing System.

The containment building, auxiliary building (radwaste area) and the fuel handling area are designed for containment of radioactive materials. The auxiliary building (radwaste area) is maintained at a slightly negative pressure with respect to outside pressure. All the exhaust air is filtered through HEPA filters prior to being discharged to the main vent stack. Off-gases from the condenser air ejector are continuously monitored and discharged without treatment into the main vent stack. Turbine building ventilation exhaust is discharged into the atmosphere without treatment through 5 roof-mounted exhaust fans. Although the FSAR indicates the steam generator blowdown tank is vented to the main stack, the applicant[19] has recently modified the system and off-gases are now released directly to the atmosphere through a separate vent stack. This change was made because of potential moisture problems in the stack sampler. During periods when primary containment access is required, the potential exists for the release of airborne activity to the environment. During the time when the containment is not secured, air is removed through the purge exhaust system prefilters and HEPA filters and discharged to the main vent stack.

During normal operation the exhaust air from the spent fuel pool area is discharged through prefilters and HEPA filters to the main exhaust fan inlet plenum for ultimate discharge through the main stack. Radiochemical hoods located in the auxiliary building are expected to contain low concentrations of activity primarily from sample analysis. Exhaust air from these hoods is passed through HEPA filters and discharged to the main vent stack.

In the Supplement to the Environmental Report dated November 3, 1971,[18] the applicant has proposed to increase the capacity of the existing gaseous waste system with three additional waste decay tanks. This modification would provide the capability to retain high activity waste for periods up to 60 days and is scheduled to be completed before the first refueling. With the modified system in operation, all high activity waste would be collected in the gas decay tanks, sampled and analyzed and if the concentration of xenon-133 exceeds the detection limit of 1×10^{-5} μCi/ml, the contents shall be held up for 60 days to permit decay of the principal radioactive noble gases except krypton-85. Gaseous wastes from containment building purging and from purging the auxiliary building are released to the environment through filters to the stack with no holdup.

b. Liquid Waste

The liquid waste system is designed to reduce radioactive materials in liquids discharged from the Palisades Plant to ensure the protection of Plant personnel and the general public from exposure to radioactivity. The system is divided into three sections: the primary waste section (clean waste), which processes high-activity liquid wastes from the primary loop; the secondary waste section (dirty waste), which treats liquid wastes from the secondary loop which may have a high chemical content but a low-activity content; and a section to handle liquid wastes from the onsite laundry.

In Amendment No. 21 to the FSAR, dated March 1, 1971,[15] the applicant describes a modification of the liquid radioactive waste system which it intends to install at or before the end of the first fuel cycle (approximately 1 year after the initial power operation). The modified system which includes the installation of two evaporators is designed to reduce radioactive materials in liquid discharges, by recycling all but the laundry wastes to levels comparable to the guidelines of proposed Appendix I to 10 CFR 50. Prior to the installation of the modified system the Plant will be operated with the liquid radwaste system described in the following paragraphs. Amendment 21 also states that after installation of the revised radwaste system under normal operation, all clean and dirty wastes will be recycled or shipped offsite except for laundry wastes, which are expected to be a minor source of activity. No credit has been given for the modified system in the estimation of the amount of activity released into Lake Michigan.

The major sources of wastes which are processed in the primary waste section are the bleed through the chemical and volume control system (CVCS) from the (10,900 cu. ft volume) primary coolant loop system at a letdown flow to the CVCS of 40 gpm, drains and controlled leaks from the primary coolant loop, the radiochemical laboratory drains, and the equipment handling drains. The primary waste discharge amounts to 137,700 gpyr from controlled leaks and drains and 586,000 gpyr bleed from the CVCS. The liquids are fed to the primary waste receiver tanks which provide for a holdup for radioactive decay of 30 days. From the receiving tanks the wastes pass through a filter to mixed bed demineralizers to remove corrosion and fission products except tritium and then to the treated waste monitoring tanks. After sampling and analysis, the liquid waste is either discharged into Lake Michigan through the circulating water discharge canal or returned to the receiver tanks or demineralizers for further holdup or processing. After the proposed installation of the modified radioactive waste system, the discharge from the treated waste monitoring tanks will be sent to a primary waste evaporator. The distillate from the evaporator will be returned to the primary coolant system through the chemical and volume control system. The concentrates will be recovered for reuse or placed in drums and handled as solid waste. With the modified system, the applicant indicates that no liquid will need to be discharged into the environment from the primary waste section under normal operating conditions.

The major sources of wastes which are processed by storage, filtration, demineralization and evaporation in the secondary waste section (dirty waste) are the primary auxiliary building floor drains, the containment sump drains and the laboratory drains. These wastes are collected in the secondary waste drain tank and processed through a filter to the waste monitoring tank. The liquid waste is sampled and analyzed and either discharged directly into Lake Michigan through the circulating water discharge canal if the activity is within discharge limits or returned to the primary waste receiver tank and processed through the radwaste demineralizers prior to discharge. The anticipated annual releases of radioactive material in liquid effluents shown in Table III-7 are based on discharges without treatment through the radwaste demineralizers.

After installation of the modified radioactive waste system, the discharge will be sent to the secondary waste evaporator. The distillate from the evaporator will be returned to the control area utility water supply for use as makeup water, and the concentrates placed in drums and handled as solid waste for offsite disposal. With the modified system, the applicant indicates that no liquid will need to be discharged into the environment from the secondary waste section under normal operating conditions.

The effluent from the Plant laundry will be collected in the laundry drain tank, filtered, monitored and discharged into Lake Michigan through the circulating water discharge canal if the radioactivity is not more than 2.5×10^{-8} μCi/ml on an annual average basis. If the activity is greater than this value, the waste will be processed in the secondary waste section. The laundry wastes are expected to be a minor source of radioactivity, since contaminated clothing may be disposed of as solid waste. Treatment of laundry waste will not be affected by modification of the radioactive waste system. After the cooling towers are in operation, the laundry wastes will be diluted by the cooling tower blowdown and further diluted by 60,000 gpm of Lake Michigan water prior to release into the lake.

The anticipated release from steam generator blowdown shown in Table III-8 is based on a continuous primary to secondary system leakage of 20 gpd and a 10 gpm generator blowdown. The blowdown is monitored and released into the lake or it may be processed through the radwaste demineralizers prior to release. The Table III-8 values are based on discharge without treatment by the radwaste demineralizers. After installation of the modified waste system, all radioactive steam generator blowdown will be sent to the secondary waste evaporator.

Under the present system all liquid radioactive wastes will be discharged through the circulating water system effluent of 405,000 gpm into Lake Michigan. The total concentration of radionuclides in the discharge into the lake, excluding tritium, is 1.4×10^{-7} µCi/ml; and the total radioactivity discharged excluding tritium is about 115 Ci/yr. The tritium concentration in the discharge canal is 1.2×10^{-6} µCi/ml and the total tritium amounts to about 1,000 Ci/yr. When the modified radwaste systems and the cooling tower are in operation, discharge will be through the cooling tower blowdown. However, the recycling of the liquid wastes in the modified radwaste system will reduce the concentration and amount of radioactivity from the clean and dirty waste sections released to the lake via the cooling tower blowdown to less than the guideline values of the proposed Appendix I to 10 CFR Part 50 under normal operational conditions. Since the radioactive steam generator blowdown will be sent to the secondary waste evaporator, any tritiated water present will likewise be sent to the secondary waste evaporator where the tritiated water vapor distillate from evaporation will be used as Plant makeup water. In this manner, no tritiated water will be released to the cooling tower blowdown nor any tritiated water evaporated during operation of the cooling towers.

The applicant has proposed Technical Specifications[19] for the present radwaste system which would limit the releases of liquid effluents to 10% of 10 CFR Part 20 limits with failed fuel. A comparison of the calculated quantities in Table III-8 with the Part 20 concentration limits indicates that it will be necessary to process some fraction of the dirty waste and steam generator blowdown liquids. The expected high concentration of solids (∿ 200 ppm) in the steam generator blowdown indicate that the dirty waste will be selected for processing. To meet the 10% of Part 20 limit, about 80% of the dirty waste must be processed through the radwaste demineralizers. Iodine-131 is the controlling isotope. The expected effectiveness of the two demineralizers is a reduction of 100 for all the isotopes shown in Table III-8, except yttrium,

TABLE III-8

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN LIQUID EFFLUENT FROM PALISADES PLANT*

Nuclide	Steam Generator Blowdown (Ci/yr)	Clean Waste (Ci/yr)	Dirty Waste (Ci/yr)
Rb-86	0.0263	0.00266	0.175
Sr-89	0.0236	0.00444	0.182
Sr-90	0.00080	0.000214	0.00669
Y-91	0.0550	4.0	0.430
Zr-95	0.00382	0.000779	0.0301
Nb-95	0.00359	0.000575	0.0267
Mo-99	6.73	0.739	9.25
Ru-103	0.00269	0.000458	0.0203
Ru-106	0.00070	0.000180	0.00584
Te-129m	0.187	0.0274	1.286
I-131	12.46	0.341	59.4
Te-132	0.846	0.000698	0.00394
I-132	0.126	$< 10^{-6}$	$< 10^{-6}$
I-133	4.22	$< 10^{-6}$	0.0496
Cs-134	0.303	0.0795	2.533
I-135	0.674	$< 10^{-6}$	$< 10^{-6}$
Cs-137	0.307	0.0824	2.578
Ba-140	0.0237	0.00152	0.141
Ce-141	0.00405	0.000624	0.0299
Ce-144	0.00244	0.000616	0.0202
Nd-147	0.00124	0.000064	0.00697
Pm-147	0.00030	0.000079	0.00251
Cr-51	0.0234	0.0327	0.168
Mn-54	0.0211	0.00536	0.175
Mn-56	0.0303	$< 10^{-6}$	$< 10^{-6}$
Co-58	0.666	0.139	5.272
Fe-59	0.0261	0.00468	0.199
Co-60	0.0204	0.00544	0.171
Fe-55	0.0469	0.0124	0.392
Total	27 Ci/yr	5.5 Ci/yr	83 Ci/yr

H-3 . . . . 1000 Ci/yr

*Releases are based on discharges prior to installation of modified radioactive waste system.

molybdenum, and tritium for which no removal is normally assumed. Under this mode of operation the estimated annual release from the "dirty waste" system would be about 25 curies per year rather than the 83 curies indicated in Table III-7. After the modified radwaste system is in effect, this estimated release would be essentially zero.

After the modified radioactive waste system is put into operation, all liquid wastes except the laundry wastes will be recycled to the Plant after being processed through filters, ion exchangers, and evaporators. Since tritium is not removed by these processes, a gradual buildup of tritium will occur in the Plant. The applicant has estimated that this buildup could reach levels of about 7.5 μCi/ml at the end of 40 years of Plant operation, a concentration which cannot be safely discharged to the environment. A buildup of tritium concentration in the primary coolant will also present some operating problems. For example, during refueling operations the operating personnel are exposed to airborne tritium resulting from evaporation of the primary coolant water from pump leakage and spent fuel pool water. Increased concentrations of tritium in the primary coolant would increase the airborne tritium concentration. To minimize the dose to operating personnel during refueling, the containment purge will be purged with fresh air and the offgas from the purge will be released to the atmosphere through a roughing filter and a HEPA filter before being exhausted to the stack. The applicant estimates that after 5 years at full power operation the tritium released by evaporation will be 19 Ci/yr and after 40 years it will be 257 Ci/yr (these represent 7% and 96%, respectively, of tritium produced per year. The excess water accumulated in the system and the final inventory of water in the reactor system must be disposed of safely. Alternatives for disposal of tritiated water include storage in large tanks onsite, injection into deep wells onsite or offsite, disposal in State-and Federally-licensed burial grounds, or discharge into the ocean. Tritiated water is now disposed of at State-and Federally-licensed burial grounds by mixing it into concrete or with betonite clay and burial of the resulting solid. The applicant in Appendix XII-13 discusses the inventory of tritium buildup during the Plant lifetime in response to the comments by the EPA on the release or effects of tritium recycle.

c. Solid Wastes

Solid wastes consist of concentrates from the waste evaporator, spent resins, and miscellaneous materials such as paper and glassware. Concentrates from the waste evaporator are mixed with cement in approved containers and moved to a shielded storage area. Spent resins from system demineralizers are flushed to a shielded, disposable, carbon steel-lined tank located in the drumming station in the basement of the auxiliary building. The resin is dewatered and liquids sent to the waste holdup tank. All solid waste will be packaged and shipped to a licensed burial ground in accordance with AEC and DOT regulations. (See Chapter V.F and Chapter VI.B on transportation of radioactive material.) Based on plants of similar size presently in operation, it is expected that approximately 10,000 ft^3 of solid radioactive wastes will be shipped annually from the site.

3. Chemical and Sanitary Waste Systems

Several routine operations of the Palisades Plant will contribute to the discharge of chemical wastes into the environment: leakage from the primary coolant system, steam generator blowdown, regeneration of demineralizers, cleaning of the condenser tubes, laundry waste operation and laboratory tests, and the sanitary waste operation. Liquid, gaseous, and solid radioactive wastes are discussed in Section III.D.2 above. These operations were initiated at the outset of operations at low power (1 MWt) in Spring 1971. In practice, 390,000 gpm of the cooling water passing through the once-through condenser and 15,000 gpm service water for a total of 405,000 gpm of cooling water serves to dilute any discharged dissolved chemicals. These discharges will be monitored by the applicant to assure that the chemical wastes discharged into Lake Michigan will meet the limits prescribed in the Order of Determination No. 931, issued on October 27, 1966, to the applicant for the Palisades Plant by the Michigan Water Resources Commission.[10] This Order of Determination imposes restrictions on the discharge of ether-extractable substances, boric acid, pH, settleable or floating solids, and other substances from the Palisades Plant. Other conditions of this Order are described above in Section III.D.1 in relationship to thermal discharge standards. As discussed above in Section III.D.1, the applicant filed an application for a Section 13 permit on all discharges with the Army Corps of Engineers in 1971 but the application is being reviewed by EPA. The applicant's water certification application under section 21(b) of the Water Quality Improvement Act of 1970 has not yet been certified by the Michigan Water Resources Commission. That application is also under review by EPA.

The standard chemicals utilized in the primary and secondary coolant systems to control pH and oxygen levels include lithium, ammonium, sodium, or potassium hydroxide, and hydrazine respectively. These chemicals are dissolved in the primary and secondary coolant to obtain the desired water chemistry. The Chemical and Volume Control

System (CVSC) described in the FSAR is designed to maintain the chemistry and purity of the primary coolant, the desired boric acid concentration, volume of water and pressure in the primary system. The applicant plans to use lithium hydroxide to control the pH of the primary coolant but only in the latter part of the core life.[17] The concentration of lithium hydroxide in the primary coolant will be approximately 1.0 to 1.5 ppm and will be discharged into the environment at a maximum concentration of 10^{-5} ppm through the primary coolant which is processed in the radwaste system. The radwaste system effluent is diluted by the circulating water discharge. When the modified radwaste system is in operation, lithium hydroxide will no longer be discharged into the environment.

Only small amounts of chemicals such as chloride or fluoride ions are present in the primary water coolant at concentrations at less than 1 ppm. A small amount of solution containing these trace elements could be leaked out through valves and seals during any leakage. The leakage and any hydrazine, which is added to the primary system for oxygen scavenging, would be diluted in the condenser cooling water and as a consequence, would not produce any measurable incremental concentrations of chemicals already present in the lake water.

Boric acid is used as a chemical shim in the primary system and any bleed from the primary system during the reduction of the boron concentration is routed to the radwaste liquid receiver tanks for processing through the radwaste system before disposal to the lake via the discharge canal. The concentration entering the lake after processing through the radwaste system will not exceed 5 ppm (order of detection limit). Approximately 60,000 lb/year of unconsumed H_3BO_3 will be discharged from the Plant.[20] After the modified radwaste system is in operation, discharge of H_3BO_3 will be reduced to essentially zero by use of evaporation which will concentrate boric acid for recycle in the Plant.[16]

During operation of the Palisades Plant, steam will be produced in the steam generator and will be condensed after passing through the turbine generator. The condensate is returned as heated feedwater to the steam generators. Hydrazine and ammonium hydroxide are added to the feedwater header downstream of the condensate pumps for oxygen scavenging and pH control, respectively. Phosphates and sulfates are also used in the secondary system to control pH. The applicant states that, assuming a maximum blowdown rate of 50 gpm and dilution of the blowdown chemicals in the condenser cooling water, the concentrations entering the lake will not exceed 0.003 ppm for phosphates and 0.0013 ppm for sulfates.[16]

Makeup water from Lake Michigan used to supply water for the primary system and other auxiliary systems is purified by demineralization prior to use in the Plant and is stored in the demineralized water storage systems or tanks ready for use in different Plant systems. Demineralizers used to purify the lake water will be periodically regenerated by adding sulfuric acid and sodium hydroxide solutions in order to form cation (hydrogen ion) and anion (hydroxyl ion) exchange resins. Thus, the regeneration process results in sodium and sulfate ions being discharged from the mixed bed resins into a 7,000-gallon neutralizer tank where the solutions are neutralized and eventually discharged into the condenser cooling water. Regeneration of the "spent" demineralizer resins occurs at the maximum rate of three times a day for a period of 6 hours each time a day (a maximum of 18 hours per day) and will result in the release, besides the two ions above, of calcium, magnesium, iron, manganese, chloride, silicate, carbonate and bicarbonate ions present in the original lake water. The maximum concentrations of these ions in the discharge water, after the regenerant solution has been discharged at a rate of 20 gpm from the neutralizer tank into the discharge condenser cooling water, are given below in Table III-9.[20] Schematics of the makeup water and chemical injection systems are shown in the applicant's "Request for Additional Information on Environmental Considerations" of November 11, 1971."[17]

Quantities of chemicals released to Lake Michigan as a result of a single makeup demineralizer regeneration are also shown in Table III-9.

Potassium permanganate to the extent of about 8 to 16 lb/yr will be used to charge the "green sand" in the sand filters which are used to filter particulate matter from lake water prior to demineralization in the Plant makeup water system. During filter backwash, this chemical will be diluted and discharged to the lake at the Plant discharge structure.[17] The calcite ($CaCO_3$) is a solid filter media used in the domestic water treatment system. The calcite is a nonconsumable material and therefore it will not be discharged to the environment.[17]

After installation of the modified radwaste system, condensate from the evaporators will be used for makeup water for the primary and secondary loops. The process water demineralizers will then be used only if the condensate does not supply the needed amount of makeup water. Following the modification of the radwaste system, liquid discharges from the modified radwaste system will be minimal during normal operating conditions.

TABLE III-9

CHEMICALS RELEASED PER DEMINERALIZER REGENERATION[1]

Chemicals Removed From Lake Michigan[2]	Pounds	Conc. Before Dilution, ppm[3]	Max. Conc. of Regenerant in Condenser Discharge ppm[4]	Max. Conc. of Regenerant in Cooling Tower Blowdown[4]
Cl^-	3.33	57.1	0.003	0.02
Fe^{++}	0.03	0.57	0.0003	0.0002
SiO_2	0.50	8.58	0.0004	0.003
Mn^{++}	0.01	0.12	0.000006	0.00004
Ca^{++}[5]	13.3	227	0.011	0.076
Mg^{++}[5]	4.0	69	0.003	0.023
$CO_3^{=}$[5]	2.0	34	0.002	0.011
$HCO_3^{=}$[5]	40.6	693	0.034	0.23
Regenerant Chemicals Added				
$SO_4^{=}$[6]	155	2,650	0.13	0.86
Na^{+}[6]	97	1,659	0.082	0.55

[1]A maximum of three regenerations per day is possible. Information on these concentrations were provided in Reference 20.

[2]Chemicals contained in lake water which are removed during demineralization and returned to the lake during regeneration.

[3]Discharged from the neutralizer tank at a rate of 20 gpm for a maximum of 18 hours per day. Concentration shown will be diluted by a flow of 60,000 gpm prior to discharge from Plant after cooling towers are placed in operation, and by 404,600 gpm with the existing once-through cooling system.

[4]These concentrations of the listed ions are discharged during regeneration for short fractions of the day in the discharge canal water and are added to those already present in Lake Michigan listed in Table III-10.

[5]The concentration of these ions is normally expressed in terms of ppm of $CaCO_3$.

[6]After installation of the modified radwaste system, the process water demineralizers will be used only if the condensate from the evaporators does not supply the needed amount of makeup water. These ions form from the sodium hydroxide and sulfuric acid added to obtain the resin as a cation or anion exchanger and are discharged to the neutralizer tank during the demineralization process. It is anticipated that the increase in the sodium and sulfate ions above that normally present in lake water will be less than 1 to 2%.

Note: The discharge will have a pH between 6.5 and 9.5.

Table III-10 compares the above chemical releases with the concentrations of chemicals already present in the lake water. Figures on the concentration of chemicals in the lake water have also been reported from data obtained from the EPA computer bank STO30WQR. The EPA values are slightly different from the numbers reported in Table III-10. All values reported in Table III-10 for the lake concentrations are within the range of values covered by EPA except HCO_3-where the value in the second column of Table III-10 is below the maximum of EPA's value of 146 ppm for HCO_3^-. Furthermore, for purposes of comparison, some data on the drinking water standards recommended by the Public Health Service[21] and the World Health Organization[22] are also presented. Table III-10 also lists for comparison the median and maximum values of certain chemicals found in the drinking water of one hundred largest cities in the United States.[23]

a. Present Once-Through Cooling System Chemical Treatment

The present once-through cooling system will have as its major chemical effluent periodic releases of not only boric acid up to 5 ppm, but also residual chlorine at 0.5 ppm at the point of discharge into the lake. Since these concentrations are both below permissible drinking water standards, they should have no adverse effect on man's direct use of this water. The effect of these chemicals on water quality for other purposes, such as propagation of aquatic life, is described in Section V.C.

Chlorine, as a 16% sodium hypochlorite solution, is added intermittently to the cooling system to remove accumulations of slime and algae growth on the inside tubes of the condenser. The concentration of the residual chlorine in the discharge stream is limited in Amendment No. 1 to the Interim Provisional Operating License No. DPR-20 granted on November 20, 1971, such that concentrations are not to exceed 0.5 ppm at the point at which the discharge water enters into Lake Michigan.[25] Concentrations of 0.5 ppm in the discharge effluent will have detrimental effects on water in Lake Michigan used to propagate aquatic life. The detriment can arise from direct toxicity of chlorine, highly toxic chloramines, or organically-complexed chlorine or from sub-lethal effects on life processes such as reducing reproduction. It can be presumed that the chlorine treatment will kill all organisms in the cooling system. Thus, there would be no survival of organisms that pass through the cooling system during the treatment period. In addition, some organisms in the lake may suffer from the toxic effects that result from the residual chlorine dispersed in the lake water. To minimize environmental damage to aquatic life, the frequency and the length of the treatment period will be limited to one hour per month. The applicant shall monitor residual chlorine concentration in the discharge water during and after the course of treatment to note

TABLE III-10

MAXIMUM CONCENTRATION IN PARTS PER MILLION OF CHEMICALS IN CIRCULATING WATER DISCHARGE CANAL[1]

Chemicals Regenerated	Ave. Conc. of Lake Michigan Water, ppm	Conc. Added to Lake From Demin. Process, ppm	Conc. Added to Lake From C.T Blowdown ppm	Cir. Water Dis. to Lake Michigan Initial Opr.[2] ppm	Cir. Water Dis. to Lake Michigan Modified Opr.[3] ppm	Recommended Limits of Conc. in Drinking Water, ppm	Drinking Water in 100 Largest Cities Median, ppm	Drinking Water in 100 Largest Cities Maximum, ppm
Cl	9.0	0.003	1.7	9.0	10.7	250	13	540
Fe	0.1	0.00003	0.02	0.1	0.1	0.3	0.02	1.3
SiO_2	2.1	0.0004	0.4	2.1	2.5		7.1	72
Mn	0.02	0.000006	0.004	0.02	0.02	0.05	0	2.5
Ca	33.6	0.011	6.5	33.6	40.1	7.5	26	145
Mg	11.2	0.003	2.2	11.2	13.4	50	6	120
CO_3	6	0.002	1.2	6.0	7.2		0	26
HCO_3	14.3	0.034	1.4	14.3	15.7		46	380
SO_4[4]	22.2	0.131	26.7	22.3	48.9	250	26	572
Na[5]	10.6	0.082	2.1	10.7	12.7	250 (TDS)	12	198
PO_4[5]	0.013	0	0.26	0.013	0.27			
H_3BO_3[5]	0	0	0	5	0	1.0		
Zn	0.010[6]	0	0.026	0.01[6]	0.036			
Residual Chlorine[5]	0	0	0.022	0.5	0.022			

Note: The discharge will have a pH between 6.5 and 9.5.

[1] Discharges will be intermittent; values given here are the maximum concentrations.

[2] Once-through cooling and present radwaste systems in operation. Concentrations include the average concentration of Lake Michigan water and the chemicals from the demineralizer regeneration process discharged at 20 gpm into 405,000 gpm cooling discharge water. See Table III-9.

[3] After installation of cooling towers and modified radwaste system. Concentrations include the average lake water concentration and the concentrations added to the lake from the cooling tower blowdown.

[4] Chemicals released from demineralizer regeneration.

[5] These chemicals are also present in the condenser cooling water but are released through other Plant operations.

[6] Rosaman, R. and Callendar, E., "Geochemistry of Lake Michigan Manganese Modules" Proc. 12th Conf. Great Lakes Research, 1969, pp. 306-316.

possible adverse effects from the chlorination treatment on aquatic biota. Discussion of the impact of residual chlorine on aquatic life is presented in Section V.C and Appendix III-1.

The Michigan Water Resources Commission added the following limitation on the use of chlorine in the applicant's Order of Determination which is considered to be an interim chlorine standard to be reviewed on or before December 1972.[28]

> "Contain not more than five hundredths (0.05) milligram per liter of total chlorine (free and combined) in the discharge channel serving each individual plant after utilizing available dilution and at a point to be determined by the Chief Engineer of the Commission, where application of chlorine is on a continuous basis; or contain not more than five tenths (0.5) milligram per liter of total chlorine (free and combined) in the discharge channel serving each individual plant after utilizing available dilution and at a point to be determined by the Chief Engineer of the Commission, where continuous application of chlorine will be limited to not more than thirty (30) minutes during any two (2) hour period."

EPA in its comments on chlorine discharges in Appendix XII-5 also recommends limitations on total residual chlorine discharges. For intermittent discharges, they are: (a) 0.1 ppm not to exceed 30 minutes per day and (b) 0.05 ppm not to exceed 2 hours per day. The EPA also recommends that control, especially critical during the winter months, could be accomplished by dechlorination with sulfur dioxide or other suitable means, and by correlating chlorination periods with high wave conditions. Furthermore, it is desirable to eliminate the possibility of synergistic effects of chlorination and cold shock by proper timing of chlorination so as not to coincide with rapid Plant shutdowns. The staff concurs that these recommendations are well taken and also recommends that the chlorination treatment should be conducted during the daytime to assure a faster reaction of residual chlorine with sunlight than during nighttime. In order to measure the low levels of residual chlorine, the recommended analytical technique is the use of amperometric titration method which is among the most accurate for the determination of free or combined available chlorine in clear water.

h. Proposed Cooling Tower System Chemical Treatment

In Amendment No. 21 dated March 1, 1971,[15] to the FSAR, the applicant describes a closed cycle cooling system which will utilize mechanical draft wet-type cooling towers, the construction of which will be completed by November 1973.[12] With this system the major liquid chemical discharge from the Plant will be blowdown at the rate of 1,320 gpm from the cooling tower. The blowdown will be diluted with lake water before discharge into Lake Michigan at a rate of 60,000 gpm (Section III.D.1.b.). The average cooling tower drift is expected to be as low as approximately 20 gpm, although a drift of 820 gpm could be reached.[12]

The recirculating water system will also be treated intermittently with sodium hypochlorite (16% NaOCl) as a biocide at a rate of 1 hour per day, creating a residual chlorine concentration of 1 ppm in the blowdown. About 1,320 gpm of blowdown will be diluted with 60,000 gpm lake water and then released into the lake during treatment periods. Residual chlorine concentration at the discharge after mixing with this dilution flow will be 0.022 ppm (Table III-10). The blowdown discharge is a continuous process.

Phosphate and zinc compounds (Calgon TG - 10'- trade name) are currently planned for use as corrosion inhibitors in the recirculating cooling water, although final choices have not yet been made. Some possible alternatives are discussed in Appendix V-1. Concentrations continuously released into the lake via blowdown (after dilution) will amount to 0.27 ppm of phosphate and 0.036 ppm of zinc, respectively (Table III-10). The concentration in the blowdown before dilution with 60,000 gpm is 1.2 ppm zinc and 12 ppm phosphate.[17]

Adjustment of alkalinity of recirculating water with sulfuric acid (also used to control condenser tube scale) will result in a continuous release of sulfate ion to the lake at a concentration of 48.9 ppm (Table III-10).[17]

4. Other Wastes

Other liquid wastes from the "hot" chemistry laboratory will be treated in the liquid radwaste system which is discussed above. Chemical wastes from the "cold" chemistry laboratory will be discharged to the sanitary waste disposal system (septic tank). Laundry effluents will be filtered and discharged to the discharge canal. On the average, approximately 3-1/2 pounds of biodegradable detergents per day will be utilized in the Plant laundry. Sanitary wastes estimated to be about 1,875 gallons of sewage per day will be processed through the facility's independent sewage system, involving a septic tank and drain field located several hundred feet south of the Plant. Based on a design flow of 25 gallons per capita day, the septic tank will serve a Plant operating staff of 75. A separate septic tank and drain field are located at the visitor's center. No sewage will be discharged to the lake.[17]

Any chemicals and hazardous materials, such as ammonia, hydrazine or organic solvents, will be stored and handled according to the common practices of industrial safety. Procedures in handling nonradioactive and radioactive materials in the laboratories will be carried out using the precautions and normal laboratory practices of safety to protect operating personnel and workers from any health hazards.

Other wastes such as trash, shop and construction debris, non-radioactive HEPA filters, septic tank sludges, etc., will be disposed of offsite by a commercial service. Large materials collected on the water intake trash racks are removed by power scoops and originally discharged to the beach via two surge channels. Small materials collected on the intake traveling screens have been flushed off by hydraulic sprays, collected in a wire basket, and discharged through the two surge channels into the lake. It will be required that all debris collected be disposed of as solid waste by a commercial service, rather than sluicing the debris into the lake through the two surge channels. The applicant is already disposing of solid wastes by commercial service in compliance with the Technical Specifications.

Miscellaneous gaseous effluents that will be discharged into the atmosphere include the gaseous effluents H_2, N_2, plus trace amounts of laboratory gases including noble gases at a rate of approximately 4,500 ft^3/yr. Hydrogen will comprise the major fraction of this discharge. Diesel exhaust from 2 generators (2,500 kWe each) will be discharged during their operating period of 2 hours per month. Except for gases from the steam generator blowdown which are monitored and vented directly to the atmosphere, all Plant gases will be discharged to the stack. The gases will pass through high efficiency particulate air (HEPA) filters which have efficiencies of $\geq$99% for 3-micron particles.[17,20]

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16. Detailed Statement of the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consumers Power Company for the Palisades Plant" Prepared by the U. S. Atomic Energy Commission, Docket No. 50-255, April 7, 1971.

17. Consumers Power Company, "Requests for Additional Information on Environmental Considerations," Palisades Plant - Docket No. 50-255," Jackson, Michigan, November 11, 1971.

18. Consumers Power Company, "Supplemental Information on the Environmental Impact of the Palisades Plant - November 3, 1971."

19. Consumers Power Company Amendment No. 24 to the Final Safety Analysis Report "Special Technical Specifications Pursuant to Agreement," June 17, 1971.

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IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF CONSTRUCTION

Construction of the Palisades Plant was essentially complete in Spring 1971, except for the addition of the modified radwaste facilities on the north end of the Plant, reconstruction of the water intake structure which had collapsed during the winter of 1970-71, and construction of two rows of mechanical-draft cooling towers south of the Palisades Plant. Reconstruction of the water intake structure has been completed, but the modified radwaste facilities are under construction. Completion of construction of the modified radwaste facilities is anticipated by Spring 1973. Construction of the mechanical-draft cooling towers has just been started but will be required before December 31, 1973 in order to meet the proposed Environmental Protection Agency (EPA) standards for thermal discharges into Lake Michigan. The applicant received all the necessary Federal, State and local permits and licenses for the construction work as described in Chapter I, Section C.

B. IMPACTS ON LAND, WATER, AND HUMAN RESOURCES

1. Area Involved

The major impact on land use occurred during the construction of the major facilities on the site. Plant site construction (prior to cooling towers) had only modified approximately 30 acres in the area of the sand dune shore belt, which is approximately a mile wide at the Palisades Plant site (Appendix II-1, Fig. 1). During construction, U. S. Highway 31 was relocated; a driveway was constructed to the Plant from the highway and a railroad spur was built besides construction of the actual Plant facilities. The applicant also exchanged land with the State of Michigan such as to increase the shoreline about 360 feet for Van Buren State Park for additional inland area for the applicant.

Most of the Palisades Plant site remains forested with the dominant forest community of red oak, sugar maple, and beech, mostly modified by forest cutting many decades ago. There are variants in recovery of this community throughout the Plant site, as well as bare sandy beaches, denuded blowout areas (free of vegetation as a result of natural or man-made disturbances), and areas where construction has taken place.[1] The Soil Conservation Service of the Department of Agriculture in Appendix XII-2 states that no prime agricultural land was involved in the construction of the Palisades Plant so the construction work does not "directly affect the crop production base of the county. Furthermore, erosion and sedimentation will be held to a minimum with water courses either sodded or cemented. Runoff water from the site should be of satisfactory quality." Chapter XII outlines agency comments on the impact on land, water and human resources from construction of the Palisades Plant.

The dominant dune soil type, Bridgman fine sand,[2] is not resistant to disturbance by traffic, and in several areas it has been blowing. Preparation of the Plant site and construction of the Plant has caused disturbances in several areas, including an area used for prestress testing of containment structures, the site of the concrete batching plant, road construction areas, power-line construction sites, and fill areas along the beach where excavated sand has been dumped.

Some construction work was also performed in Lake Michigan. A channel was dredged and back-filled along the beach to bury the inlet pipe for cooling water. Barges were sunk offshore to act as breakwaters during construction but have since been removed. A small harbor was dredged south of the Plant to permit unloading of the pressure vessel from a barge, and pilings for this harbor are still in place. Part of this harbor has filled in with sand as a result of wave action on the shore, and more widening of the beach can be expected in years of low or lowering lake level.[3]

Construction of two rows of cooling towers on the existing Plant site will require clearing approximately 100,000 square feet of a partially wooded area between dunes (see Fig. II-2 for proposed site of the cooling towers). Excavation of sand also will be required. The sand will be relocated in low areas inland of the dunes as fill for expected expansion of the electrical transmission switchyard, located as shown in Fig. II-2.

In Section III.B the effect of the construction of the needed transmission lines on the land area is described. A total area of 5 acres of dune area had to be cleared for the construction of the short section of transmission line to connect with the 345-kV interconnection. Construction of the Palisades Plant resulted in adding 1/2 mile of transmission lines over its own property to an already existing and operating network. Whenever possible, existing blowout areas were used for the transmission line corridors to prevent unnecessary clearing of the land. A 40-mile line involving a total area of 2,250 acres of gentle rolling terrain, used primarily for farming, was built in 1969 to connect the Plant to the interconnection with its partner in the Michigan Power Pool and its customers. The applicant will be required to conduct normal inspection of the right-of-way for the transmission line in such a way to eliminate the need to keep the right-of-way cut back in wooded areas. Clearing should be limited to only permit access of maintenance vehicles and to keep the line free from intrusion of timber which would interfere with the safe operation of the line.

2. Manpower Effects

Since most workers commuted from nearby communities to the Plant site, the impact of manpower on the local environment was negligible. There was increased traffic on the local roads during construction but four-lane highways were sufficient to handle the increased traffic load in the area. Little impact of construction was felt in local schools and businesses in South Haven, Michigan, the nearest community to the Plant. The applicant leases farmland to landowners to allow continued use of the land for agriculture. Orchards were left intact wherever possible.

3. Environmental Considerations

The major environmental impact of site preparation and construction has been the alteration or destruction of plant communities in the dune belt that stabilize the dunes against erosion and provide habitat for the wildlife species in this area as discussed in Section II.E.

The construction site was formerly a sand quarry, and additional excavation was required for construction. This sand has been relocated along the beach to the north and south of the Plant and as fill for both the railroad spur and the access road from U. S. Highway 31 to Plant facilities (see Fig. II-2). The fill areas along the beach are predominantly bare sand with scattered growth of forbs, beach grass (Ammophila breviligulata), and sand reed grass (Calamovilfa longifolia). Several of the disturbed areas and the fill area along the beach are eroding from both wind and water.

Construction in Lake Michigan has probably had negligible impact on aquatic communities. Most of the construction occurred in a small area of the sterile zone in inshore waters in which populations of benthic organisms are low due to the shifting sand bottom.[4] Reconstruction of the water intake structure also should have negligible impact on aquatic communities in the lake.

Any increase in noise levels generated during construction of the Plant's major facilities has since diminished. During construction the applicant installed mufflers on steam exhaust lines to diminish this source of occasional noise. Furthermore, no increase in noise levels at the site boundary above present background levels in this area should occur as a result of the remaining Plant construction. No unpleasant odors resulting from Plant construction have occurred nor are expected during the remaining construction work.

C. CONTROLS TO REDUCE OR LIMIT ENVIRONMENTAL IMPACTS

Landscaping with native species and replanting of fill and other disturbed areas will enhance the appearance of the Palisades Plant site and reduce the erosion of these areas. The area immediately adjacent to the Plant has been and will be planted with trees, shrubs, lawn and dune grasses to stabilize any sandy soil. Removal of construction debris and temporary facilities after completion of construction also will enhance the appearance of the site. However, construction of cooling towers is likely to produce a more serious impact on the site than all previous construction unless special care is taken. The plant communities are sensitive to disturbances and require several years for pioneer species of plants to reinvade disturbed areas.[5,6] The natural process of succesion and stabilization of plant communities on the dunes is accelerated if the disturbed areas are replanted with pioneer species (dune grasses named above) rather than being left alone to recolonize naturally. Replanting helps to stabilize the eroding areas by preventing severe wind and water erosion and enhance the natural appearance of locally adapted shrubs and native trees on the Palisades Plant site. Most of the disturbed areas on the site have been replanted at least once, but failure of some plantings illustrates the vulnerability to disturbance. The fill areas along the beach and the areas, which will be disturbed for construction of the cooling towers, should be stabilized initially with grass clumps after completion of operations and, also, each time that heavy wave erosion and dune undercutting are followed by a lowering of lake levels.[3,6] It is particularly important that the protective, partly stabilized dune ridges parallel with the beach, between the beach and the planned cooling tower areas, be disturbed as little as possible to prevent, or at least minimize, new areas of wind tunneling and sand erosion. The staff recommends that the applicant keep in contact with State and local authorities on constructing nature trails, landscaping and replanting dune grasses where necessary to restore the site.

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V. ENVIRONMENTAL IMPACTS OF PALISADES PLANT OPERATION

In this chapter the effects of the Palisades Plant normal operation on the environment are described and assessed. They are divided into two principal categories: (1) those that affect man directly, e.g., exposure to radioactive materials, the consequences with respect to water use, and impacts on land use, and (2) those that have direct impacts on biological systems that man uses commercially or for recreation, or which he wishes to protect for future generations. Two modes of Plant operation are planned, initially with open-cycle, once-through cooling, and subsequently with closed-cycle, mechanical draft cooling towers. The organization of this chapter gives sequential treatment to the two types of operations. Since the design characteristics of the proposed cooling tower systems have not been fixed, some of the assessments of the impacts that may result from their operation are necessarily tentative. The relative significance of the impacts of Plant operation under these two modes is summarized in Chapter VII.

A. LAND USE

1. Effects of Operation of Open-Cycle, Once-Through Cooling System

a. Aesthetics

The major impact on land use in regard to operation of the Palisades Plant occurred during Plant construction and construction of transmission lines as described in Chapter IV. The major aesthetic impacts on the land resulting from operation of the Palisades Plant are the use of uncultivated land on which construction of man-made facilities such as buildings, parking lots, transmission lines, and electrical switchyards, and breaking the beach profile with the sheet pile effluent channel occurred. The applicant has exerted effort to reduce the impact of these facilities; the site has been landscaped; grass has been planted to help prevent sand erosion; modern industrial features have been incorporated in the Plant buildings; and, where possible, existing blowout areas were used for transmission line corridors to prevent unnecessary clearing of the land; and land used for transmission corridors continues to be used for agriculture purposes through leasing land back to landowners and farmers.

A tourist information center is located on the Plant site as a part of the applicant's public relations and educational efforts.

Its aesthetic impact is considered to be negligible; it could be termed positive because of its modern architectural features that blend with the natural landscape.

b. Access

The perimeter of the Palisades Plant site is posted but does not prevent access to the site; however, the immediate area of the Plant facilities is fenced in. Access to the site can be gained from Lake Michigan, along the beach from either direction, and from U. S. Highway 31 via a secondary road through the sand dunes. The applicant prefers, however, that all visitors enter through the visitor's center, which is adjacent to the secondary road.

The entire beach behind the Plant, excluding the discharge canal, is available for public use; the cooling water discharge is fenced in, which prevents passage along the shore. At the suggestion of the staff, the applicant gave consideration to the construction of a pedestrian bridge across the discharge structure. When the local groups both north and south of the site learned of this possible action they expressed unanimous objection and the plan was terminated.

Water access is unrestricted, although safety warning signs will be placed in the discharge canal. The discharge velocity (2 fps) should not deter people from using the immediate area for wading or boating.

The applicant has plans for building nature trails and allowing controlled hunting by archery only in the surrounding dunes area within its site. Visitors to the Van Buren State Park, north of the site, and Covert Township Park, south of the site, will have access to these trails.[1]

c. Winter Shore Erosion

During winter months the heated circulating water effluent will melt some Lake Michigan ice in the vicinity of the discharge structure. Some shore erosion may occur at this time due to the effect of the heated discharges in melting ice near the discharge structure. Ice which forms along the shore helps protect the sandy shoreline from erosive wave action during the winter season. Unique circular current patterns of the southern Lake Michigan basin distribute drifting floes of ice along the shore, and even during the mild winters these floes become consolidated and extend from the shore out into the lake.[2] In severe winters this consolidated zone can extend 10 to 15 miles into the lake, but generally it extends only a few hundred yards. Beyond the consolidated zone there exists a zone of unconsolidated, but densely packed floes that blend into progressively more open water. An "ice foot" generally accumulates upon the beach, composed of frozen spray of lakewater, snow accumulations, stranded ice floes, and sand that is thrown up by wave action or blown out from the beaches.[2,3] Marshall[3] has adequately described the formation, appearance, and breakup of this ice cover.

The evidence available from aerial, boat and on-foot ice studies at Lake Michigan power plants during the winters of 1969-70 and 1970-71 shows that discharges of waste heat do not cause extensive melting of shore ice with resulting exposure of the beaches to wave erosion.[4] Data show that the type of outfall structure used at Palisades, a double sheet pile canal leading out into the water, will have shore ice continuing up to the sides of the canal. The unconfined outfall channels of the Big Rock and Campbell Stations have been studied for several winters. Each winter the Big Rock discharge melted a narrow channel of limited length outward into the solid sheet ice of Little Traverse Bay, and shore ice came up to the very edges of the outfall canal. At Campbell during winter, there has been a considerable area of melted shore ice, but beach erosion has not been evident. Offshore discharges such as those from Big Rock City allow shore ice to accumulate in apparently normal fashion behind a small melt hole. However, the unconfined natural mouths of even small streams appear to be capable (without man-made heat) of destroying substantial amounts of the protective shore ice.[4]

This small impact may be due, in part, to the tendency for a thermal plume to sink in winter when dilution with surrounding cold water has reduced temperatures to about 39°F (4°C), the temperature of maximum water density (refer to discussion of thermal effluent dispersion in Section III.D). However, it is expected that erosion of the shoreline will only occur close to the discharge structure because of erosive wave action during the winter season.

Thus, little more wave action is expected to reach the beach at Palisades site than if there were no thermal discharges. Any wave action which does reach the beach because of thermal discharges would be expected to affect only the portion of the beach controlled by the applicant, which extends over 2,000 feet on each side of the discharge structure.

d. Climatic Effects

The atmosphere will ultimately absorb most of the waste heat from the Palisades Plant, with the Lake Michigan water acting as an intermediary during the dispersion of the thermal discharge in the circulating water primarily on the surface of the lake. Based on many years of observation at power stations,[5] no serious atmospheric effects are expected from heat by the once-through cooling system. Wispy steam fog over the thermal plume may occur, depending on the vapor pressure of moisture in the air and the temperature isotherms of the plume.[5,6] Church[5] 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 vapor saturation and condensation. Further vertical mixing tends to evaporate the steam fog. However, any observed steam fog is not expected to be thick nor rise but a short distance off the lake surface. 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. It is not expected that the density of the fog will be sufficient to interfere with shipping or other modes of transportation on the lake. Furthermore, no effect from the steam fog on the lake surface is expected inland because of high air turbulence. The fog will disperse very quickly and will not persist for any period of time, particularly with relatively high air flow currents across the large surface of the lake.[5,6] Some of the water droplets will be removed by vegetation and other surfaces as they move across the shoreline, causing a local increase in humidity and dew.

2. Effects of Operation of Closed-Cycle Cooling System

a. Aesthetics

The cooling towers will produce an additional change in land impact resulting from the proposed closed-cycle heat dissipation system. The towers will not be visible from U. S. Highway 31 or Highway I-196, because of the sand dunes between the towers and the highways. The towers will not obstruct the view along the beach as they are designed to be hidden from view except from the lake. The cooling towers themselves should, therefore, be of aesthetic significance only from the lake side of the site.

The major aesthetic effect associated with the proposed cooling tower operation will be the long water vapor plumes resulting from this method of heat dissipation. These plumes will be visible from both U. S. Highway 31 and Highway I-196. Any adverse aesthetic effect from these plumes should be minimal if, according to the applicant's consultants, they are visible over the Township of Covert less than 57 hours each year and visible over South Haven less than 1 hour each year as claimed.[7]

b. Climatic Effects of Cooling Towers

The atmosphere will directly absorb the waste heat from the Palisades Plant during operation with cooling towers. Whether adverse effects on the atmosphere will occur either on a large or small scale is a matter of speculation. Whether a diffuse disposal from a nearly point source such as cooling towers results in an adverse impact on the atmosphere is unclear at present. Smith[8] has analyzed the use of the atmosphere as a heat dump and concluded that the use of the atmosphere for this purpose would be appropriate, provided there are controls to limit development of any adverse effects. The locally intensified effects from cooling tower plumes are possible particularly during spring and fall. Regional effects of cooling towers at Palisades will very probably be small (a conclusion based on studies near Lake Meade and similar man-made systems),[9] although Lake Michigan itself clearly has a direct effect on winds and moisture which, in turn, modify temperature and regional weather of nearby land.[10] No global climatic problems due to rejection of waste heat from the Palisades Plant cooling tower plumes are anticipated during its lifetime operation.[11,12]

In regard to evaluating the possibility of formation of induced local ice and fog from the cooling tower plumes, an extensive study to determine the environmental effects of cooling tower plumes was made by Nuclear Utilities Services Corporation (NUS) for the Palisades Plant.[7] Results of this study indicate that, although meteorological conditions contributive to aerodynamic downwash frequently occur at the Palisades site, particularly during the winter, the visible plume from the proposed mechanical draft cooling towers will seldom directly contact Highway I-196. Likewise, induced fogging and icing effects will be negligible throughout the offsite area. However, visible fog production and icing effects will occur more frequently onsite than offsite.

In reference to precipitation, mechanical cooling towers of the type planned for installation at the Palisades Plant will disperse water to their environs by evaporation and drift. Evaporation of the cooling tower water will amount to about 12,300 gpm. Drift occurs as droplets of the recirculating cooling water, which are caught up in the rapid flow of air, are ejected out of the top of the tower and fall as a mist on the land. The water loss from the drift could be as high as 820 gpm from the Palisades towers, with a probable average value of 20 gpm. This additional "rainfall" may affect the immediate surrounding land area (see further discussion in Section V.C.2.). Since the affected area is currently wild forest and grass, and not suitable for agriculture, the result may be a minor impact on wildlife cover and food. Additional moisture may stimulate growth of wild vegetation.

c. Chemical Effects

Chemicals added to recirculating cooling water as corrosion inhibitors in the cooling towers and naturally present chemicals which are concentrated by evaporation will also be distributed on the surrounding land by the cooling tower drift. A tentative list of chemicals to be found in the drift from the Palisades towers is given in Appendix V-1, Table V-1. Appendix V-1 discusses chemicals generally used in cooling towers and potential loss rates from drift. These chemicals may affect use of land surrounding the cooling towers due to potential effects on vegetation (see further discussion in Section V.C.2.). Toxic chemicals, particularly if used in excess, have the potential of reducing or destroying the present wild nature of the area, although such effects are not well-established.

d. Noise

The proposed mechanical draft cooling towers will utilize large, high speed, rotating equipment to drive large quantities of air through the restricted tower flumes to dissipate heat to the atmosphere. These conditions will produce a noise level of about 85 db at a distance of 100 feet from the face of the tower.[7] The nearest site boundary is approximately 1,500 feet south of the the proposed site. This distance, the terrain, and the foliage between the towers and the boundary should reduce this noise level to a minimum at the site boundary. One can expect the noise to have some impact on the amount of wildlife within the fenced area.

B. WATER USE

1. Effects of Present Once-Through Cooling System

a. Thermal Effluents

The once-through heat dissipation system of the Palisades Plant should have no thermal effect on local groundwater but will produce a thermal plume in Lake Michigan, the size, shape, and behavior of which are discussed in Section III.D.1.c. Lake currents are expected to flow parallel to the shoreline more than 54% of the time, thus favoring the occurrence of a thermal plume adjacent and parallel to the shoreline during southwest and northwest winds on the lake.[13] (Thirty percent of the time offshore currents occur and 6% of the time there is a calm.) The 1 F° excess isotherm of this plume, as noted in Section III.D.1.c., may exist 12 miles along the beach from the discharge point during strong alongshore current conditions on the lake. This should have no adverse effect on man's direct use of these waters and may possibly enhance the use of the beach waters for swimming and other related water recreation. Indirect impacts through effects on lake biota are discussed in Section V.C. and Appendix V-2.

In terms of water use, the volume of circulating water passing through the intake-discharge system, amounts to about 405,000 gpm or 0.017% of the total volume of Lake Michigan in an entire year.

The intake structure, 20 feet below the surface of the lake, should not affect the use of the lake surface waters for boating. Likewise, the cooling water discharge, with a velocity of 2 fps, should have no effect on water activities in the immediate area.

In regard to thermal effects, increasing the circulating water temperature by 25 F° during full power operation is not expected to produce a significant change in the dissolved oxygen content of Lake Michigan water as it passes through the Palisades Plant. Thus, no change in the ability of the lake water to assimilate organic wastes is anticipated. This conclusion is based upon review of world-wide literature relevant to this question[14] and upon operating experience of power plants on Lake Michigan.[15] Cooling water discharges tend to slightly increase the dissolved-oxygen content of water where concentrations are low and to reduce it where they are above saturation.[16] Dissolved oxygen is discussed further, with reference to aquatic life, in Section V.C.

b. Turbidity

Turbidity of the lake water may possibly increase because of operation of a once-through cooling system at the Palisades Plant.[17] From observation during a site visit, the regulatory staff found no basis for turbidity to increase in the lake water. Operation of the circulating cooling system will not result in an addition of suspended solids to the water flow during passage through the intake-discharge structure of the Plant. Any additional suspended matter may be derived from disturbance of lake bottom sediments at either the intake or the outfall. Bottom scouring at the intake seems unlikely. The Palisades Plant intake is located 6 feet above the lake bottom, and the intake velocity of 0.5 to 0.6 fps at the crib of the intake structure is considerably lower than those of the normal shore currents.[18] In addition, the bottom materials are sands that do not contribute to turbidity even when disturbed.[13]

Scouring is expected at the discharge, but should not contribute to turbidity. The flow rate of 2 fps at the discharge is sufficiently high to move finer sand particles but is not expected to cause any significant change in natural lake current patterns and associated sediment movement over a large area of the bottom of the lake. On a site visit, the regulatory staff confirmed the fact that the discharge embayment has been scoured already, since the bottom is composed largely of small gravel. The sand carried by shore currents will undoubtedly be swept out of the immediate discharge area as fast as it accumulates on the upcurrent side. The sand particles are sufficiently large that any which are disturbed will settle almost immediately outside the discharge structure and thus no increase in turbidity would be produced.

In some areas of the Great Lakes, storms create turbid or "roily" near-shore waters by agitating the clays derived from glacial till sediments in shoreline banks or in bottom materials. Continued water movements induced by a power plant discharge could prolong the time that these clay materials remain suspended or could propel them farther out into the lake. The shoreline of southeastern Lake Michigan has few exposures of glacial till, however, so this type of induced turbidity should not be great.[15]

c. Chemical Effluents

As shown in Table III-10, of Chapter III, the present once-through system will have as its major chemical effluents periodic releases of boric acid at 5 ppm and residual chlorine at 0.5 ppm at the point of discharge into Lake Michigan. Since these concentrations are both below permissible drinking water standards,[18] they should have no adverse effect on man's direct use of this water. The effect of these chemicals on water quality for other uses, such as propagation of aquatic life, is discussed in Section V.C.

2. Effects of Closed-Cycle Cooling System

a. Thermal Effluents

As discussed in Section III.D.1.c., the proposed closed-cycle heat dissipation system may produce, during strong alongshore current conditions, a thermal plume having a 1 F° excess isotherm that covers an area of approximately 24 acres and extends about 2 miles along the shore from the discharge point. This should reduce to a minimum the thermal impact on man's use of the lake waters.

b. Turbidity

Cooling tower blowdown water may be somewhat more turbid or more colored because of concentration of the salts already present in lake water and the addition of treatment chemicals (see following section and Appendix V-1). No significant increase in turbidity, however, is expected in lake water following dilution of blowdown at the outfall. Closed circuit cooling would reduce any influence of the discharge on storm-induced turbidity of the lake, due to the smaller volume discharged.

c. Chemical Effluents

Operation of cooling towers affect the chemical water quality by: (1) concentrating naturally occurring chemical constituents in the makeup water, and (2) adding chemicals used to control corrosion and fouling. A tentative list of the principal chemicals to be released in the Palisades Plant blowdown and their concentrations at the discharge into the lake is given in Tables III-9 and III-10. None of the chemical concentrations shown in this list are higher than drinking water standards,[16] and thus they present no direct problem to man's use. Compounds containing phosphate and zinc ions that are proposed for use as corrosion inhibitors will be critical problems for use of Lake Michigan water for propagation of aquatic life, as will the principal alternative - chromates. Chlorine will also be used as a biocide but at less than 1% of the amount concentration used during operation of the once-through cooling system. These impacts are discussed under biological impacts, Section V.C., and in Appendix III-1.

The evaporative cooling towers at Palisades will contribute to the long-term buildup of dissolved solids in Lake Michigan over the past century that has been documented by Beeton[18] (Fig. V-1). This buildup affects a wide variety of water used, ranging from industrial uses to propagation of aquatic life. The towers will have only a small influence, however, relative to the discharges into the lake of tributaries, sanitary wastes, and industrial discharges near the Palisades site, but their effects cannot be discounted.

Radiological effects on man's use of the receiving waters are discussed in Section V.D.

d. Oils and Other Petroleum Products

Closed-circuit cooling will involve the use of additional machinery through which cooling water will have to pass, including additional pumps and air fans. This increases the risk of inadvertent contamination of lake water with petroleum products used for lubrication, a risk that is normal of operating cooling towers as well as possibly due to accidental releases. These products are unsightly; they can be toxic in high concentrations which, however, are unlikely at Palisades and small amounts can taint the taste of water and fish flesh.[17] Operating experiences at other sites suggest that these impacts, while identifiable in principle, will not be great.

e. Dynamics of the Water Budget

In operation, mechanical-draft cooling towers remove heat from the circulating water by evaporation. Evaporation of about 1 lb of water will transfer approximately 1,000 Btu to the atmosphere. Evaporation of 1% of water volume will result in a reduction of the water temperature by approximately 10 F°. Water is also removed from mechanical-draft cooling towers by drift and blowdown.

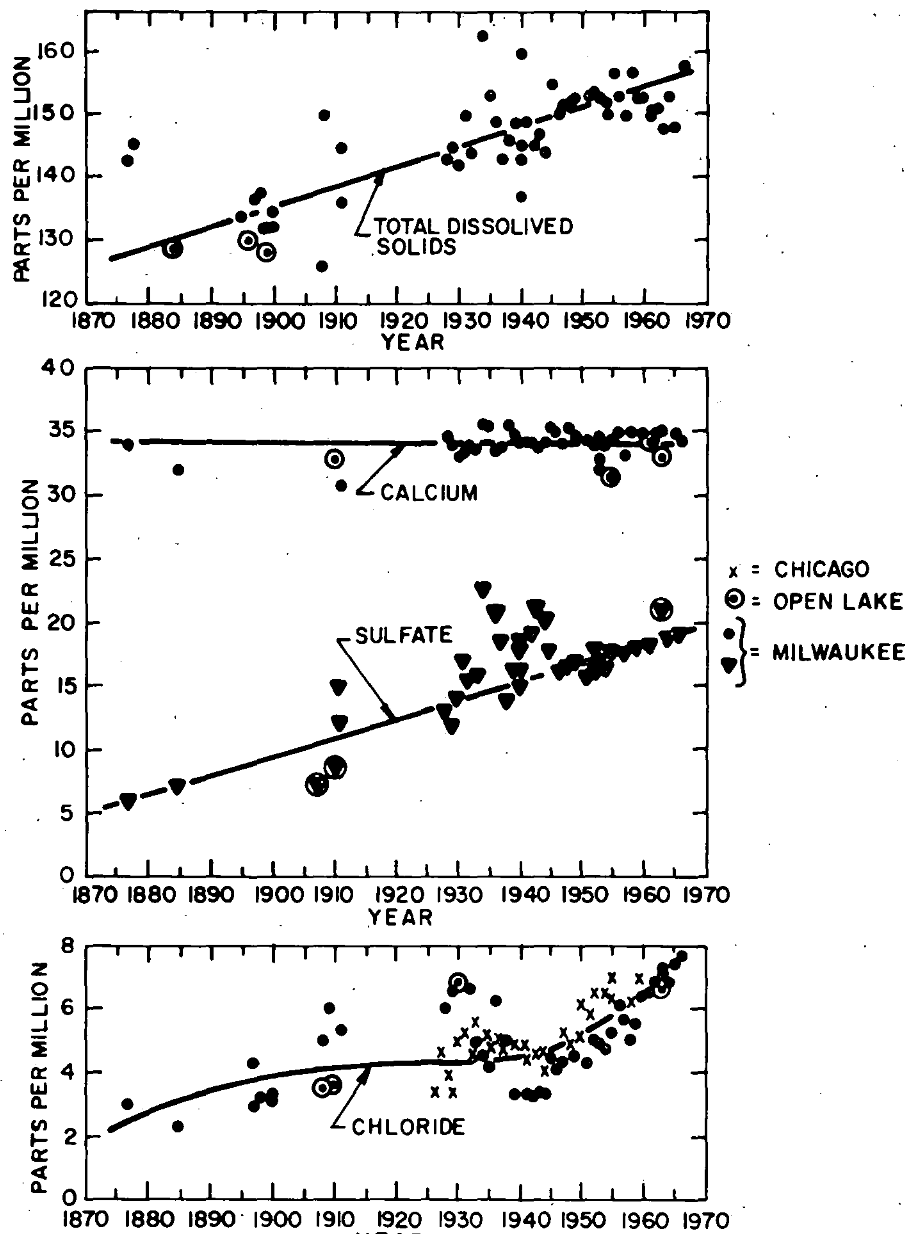

Fig. V-1
CHANGES IN THE CHEMICAL CHARACTERISTICS OF LAKE MICHIGAN
(Ref. 18)

Drift, the carryover of water droplets by air, accounts for a small loss. Cooling tower manufacturers will guarantee that the losses from drift will not exceed 0.2% of the water circulated. In some towers of the most advanced design, losses are confined to lower volume fractions, often less than 0.1 of the standard limit. Drift eliminators can be used to minimize the amount of drift lost to the atmosphere.

Maximum values of water losses from the cooling towers proposed for the Palisades Plant have been estimated by one of the vendors (the Fluor Corporation) to be 820 gpm as drift with typical values of drift possibly as low as 20 gpm and 12,300 gpm as evaporated moisture. Blowdown accounts for the remaining mode of discharge of water from the towers. In present cooling tower technology, discharge of about 0.3% of cooling water as blowdown is effected per 10 F° of cooling so as to prevent the development of concentrations of solids in the recirculated water at concentrations exceeding three or four times that of the makeup water. The blowdown rate for the Palisades Plant has been estimated to be 1,320 gpm. Thus, a total amount of 13,640 gpm of makeup water, to be supplied by discharge of the service water cooling system, will be needed for operation of the cooling towers.

C. BIOLOGICAL IMPACTS

This section treats impacts of the Palisades Plant (except radiological impacts) on organisms other than man. Many of these organisms are of immediate importance to man through commercial fisheries, sport fisheries, or biological nuisances. Others are important as food-chain contributors to those species of more direct interest. Still others are important components of the entire ecosystem, without which the normal patterns of nutrient cycling, decay of organic matter, and other essential processes in the lake could not proceed.

The following discussion is twofold. To clearly define impacts upon ecological systems, it is necessary to segregate the portions of the biota (e.g., fish) on which the impacts will be felt, and then to analyze the nature and severity of these impacts on those particular organisms using the best available data from reliable and publicly documented sources. On the other hand, some impacts (and the means for remedying them) are better described in terms of the source of the impact (e.g., chlorine). There is necessarily some overlap and attendant redundancy. Several sources of impact are discussed first, followed by more detailed descriptions of various components of the biota. As in the previous section, two alternative cooling systems are analyzed.

1. Effects of Once-Through Cooling System

a. Sources of Potential Biological Damage

There are six principal sources of potential biological damage from the once-through cooling system (and a seventh, their combined effects):

(1) Temperature increases from the discharged cooling water, causing both direct effects and indirect effects (metabolism, growth, disease, predation, etc).

(2) Mechanical and pressure changes that damage small organisms passing through pumps and condenser tubing.

(3) Impingement on intake screens of larger organisms, principally fish, drawn into the cooling-water intake.

(4) Chemicals used as biocides (usually chlorine) to remove slimes from the condenser tubing, and perhaps other chemicals released to the cooling water from a variety of Plant operations, all of which may be toxic to aquatic life.

(5) Induced circulation of a water body, both in the local area of the discharge (which may influence migrations) and in the wider range of the water body (changing normal seasonal patterns).

(6) Radiation derived largely from radioactive nuclides taken up by terrestrial and aquatic organisms, which could potentially induce radiation damage if concentrations of the nuclides were sufficiently high.

(7) Combinations of the above, which may cause effects greater than the sum of individual effects (synergism).

The probable impact of these and other potential sources of biological impact on Lake Michigan have been the subject of recent active debate.[19,20] As a result of the strong assertions concerning detrimental effects of thermal discharges in the lake via a once-through cooling system, the applicant agreed to install a closed-cycle cooling system.[1,21]

(1) Temperature Increases

Temperature controls the rates of most ecological processes and increases in temperature from the thermal plumes may cause direct and indirect effects (metabolism growth, disease, predation, etc.,) on biological systems. More is known about its effects than can be reviewed here (general references are available, and several are cited here as examples.[22-27]). Its effects on the biota of Lake Michigan can best be described in a detailed discussion of each major biological component of the ecosystem, or of particularly important species. These discussions follow in V.C.1.a, c and d and in Appendix V-2.

(2) Mechanical and Pressure Changes

Organisms drawn with cooling water through the circuit of screening, pumping, pressure changes, and outfall turbulence often sustain mechanical breakage that generally results in death. Mechanical effects have only recently been studied separately from other effects at operating power stations, and most results are available only in the form of progress reports. Limited evidence suggests that from 15% to 100% of the organisms may be killed, depending largely upon organism size. Losses of about 30% may be more representative. These high mortalities may be balanced by short generation periods of many lake species. A more detailed discussion of possible effects at the Palisades Plant is given in the sections on phytoplankton and zooplankton (V.C.1.c).

(3) Impingement on Intake Screens

Most power plant cooling systems include traveling screens made of wire mesh (generally 3/8-inch mesh) to exclude large particles from the condenser. The large particles often consist of fish when the intake is near fish habitat and intake velocities exceed cruising speeds of the fish. Significant fish kills at other power plant sites have resulted from impingement of fish on traveling screens.[28,29]

The likelihood of the Palisades Plant intake drawing in fish is discussed under each of the principal fish species in Appendix V-2. In summary, the intake crib is well located to avoid most fish with the possible exception of the American smelt. It, too, may not be affected significantly since the intake is not in a restricted migratory pathway, only in a general depth zone where the species is known to occur. A low horizontal intake flow velocity of 0.5 to 0.6 fps is maintained at the edge of the crib to minimize the possibility of drawing fish into the structure. According to the applicant, a similar arrangement has been successful at the Big Rock Point Nuclear Station. High flow velocity in the intake piping (9 fps), however, will preclude safe return to the lake of any fish that do enter. All such fish will die by impingement on the traveling screen, carried above water, and deposited in a dry trash basket.

TABLE V-1

EXAMPLE OF NUMBER AND LENGTH OF FISH COUNTED DAILY
AT THE INTAKE SCREEN FROM JANUARY 23-FEBRUARY 22, 1972

N = Number; L = Length in Inches

DATE / SPECIES		1-23	1-24	1-25	1-26	1-31	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-11	2-12	2-13	2-14	2-15	2-16	2-17	2-18	2-19	2-20	2-21	2-22
ALEWIFE	N						25			200	80		12					10										
	L						?			1-6	?		?					4										
BURBOT	N			2	2	2		2	2			3									2							
	L			20,24	20	?		8,10	16			?									18,25							
CARP	N			11			2																					
	L			3			3																					
COHO SALMON	N					1		3				1																
	L					pieces		pieces				pieces																
LAKE TROUT	N										1	2																1
	L										14	16,28																24
BOWFIN	N					2	4				3	4	2		2	5		1	1						3	2		
	L					?	14				?	?	?		?	?		18	20						13-18	15-16		
PERCH	N		2	15	1			1		5	17	5	5	1	4							1			2			1
	L		4-5	3,7-10	6			3		10	6-10	?	?	8	?							8			6,10			10
SCULPIN	N	18	37	351	40	12	4	35	8		80	80	90	25	25	32		18	8		5				27			
	L	4	3-4	1-3	?	?	3-5	3-4	3-5		?	?	?	?	?	4		?	?		4				3-5			
SMELT	N			1	3			6							1	10		4										
	L			6	8			?							?	3		8										
RAINBOW TROUT	N			2	2				1			1																
	L			10	8-10				6			14																
SUCKER	N		2	6	2	1	2				4	2	3	3		3			1		2	1			2	1		
	L		18,4	12-20	16,20	24	4-6				9-19	20	10-20	15-18		10-20			20		20	10			6,8	20		
CHUB	N			1			1																					
	L			6			3																					
CHANNEL CATFISH	N																					1						
	L																					8						
CHINOOK SALMON	N																											
	L																											
CISCO	N																											
	L																											
TOTALS		18	41	389	50	18	38	48	11	205	185	98	112	29	32	50	0	33	10	0	9	3	0	0	34	3	0	2

It appears essential that this possibility be examined carefully during the first year of operation, and accurate records maintained of numbers, sizes, and types of fish actually killed. If more than incidental numbers of fish are drawn into the intake, then the feasibility of alteration or screening of the intake crib, or installation of a fish by-pass at the screen well, should be examined and a method selected to reduce losses. The applicant's operating experience with impingement during interim operation at low power during winter and spring 1972 is summarized in Table V-1. The principal mortality is of sculpins in January and February. Total numbers of fish impinged on the screens and counted daily from February 24, 1972, through March 26, 1972, ranged from 0 for 22 days up to 16 per day for 10 days.

(4) Chemicals Added to Environment

(a) Chlorine

The Palisades Plant will use chlorine (as sodium hypochlorite) intermittently to reduce growths of algae and other microorganisms in the cooling water piping. Since detrimental effects on aquatic life in Lake Michigan will result from the toxicity of chlorine, highly toxic chloramines, or organically-complexed chlorine, or from sublethal effects on life processes such as reducing reproduction, as discussed below, the regulatory staff will require limitation of the concentration, the frequency and duration of chlorination treatment of the once-through condenser system. Details of effects on biota will be found below in sections on the various biological components of the lake ecosystem (e.g., phytoplankton, zooplankton, etc.). As discussed below, the concentration believed safe for aquatic life is no greater than 0.003 ppm, based on rearing experiments in the laboratory with the bottom invertebrate, *Gammarus pseudolimnaeus*.[30] Rainbow trout have been observed to avoid chlorine residuals of 0.001 ppm.[31] Additional toxicity data are summarized in Fig. V-2 and Table V-2.

Dilution of the residual chlorine in the effluent plume in Lake Michigan would expect to reduce the available chlorine of the Palisades effluent to levels that can be presumed to be reduced by the same pattern as the temperatures; however, since chemical reactions will reduce residual chlorine in the lake, dispersion of the chlorine plume equal to that of the thermal plume is an upper approximation. The heat dissipation model is the best approximation of a dilution model available, however, and probably is one that over-estimates (for greatest safety) the residual chlorine concentration. Thus, a level of 0.0034 ppm found to affect reproduction of the bottom invertebrate *Gammarus* may occur over about the same area as a

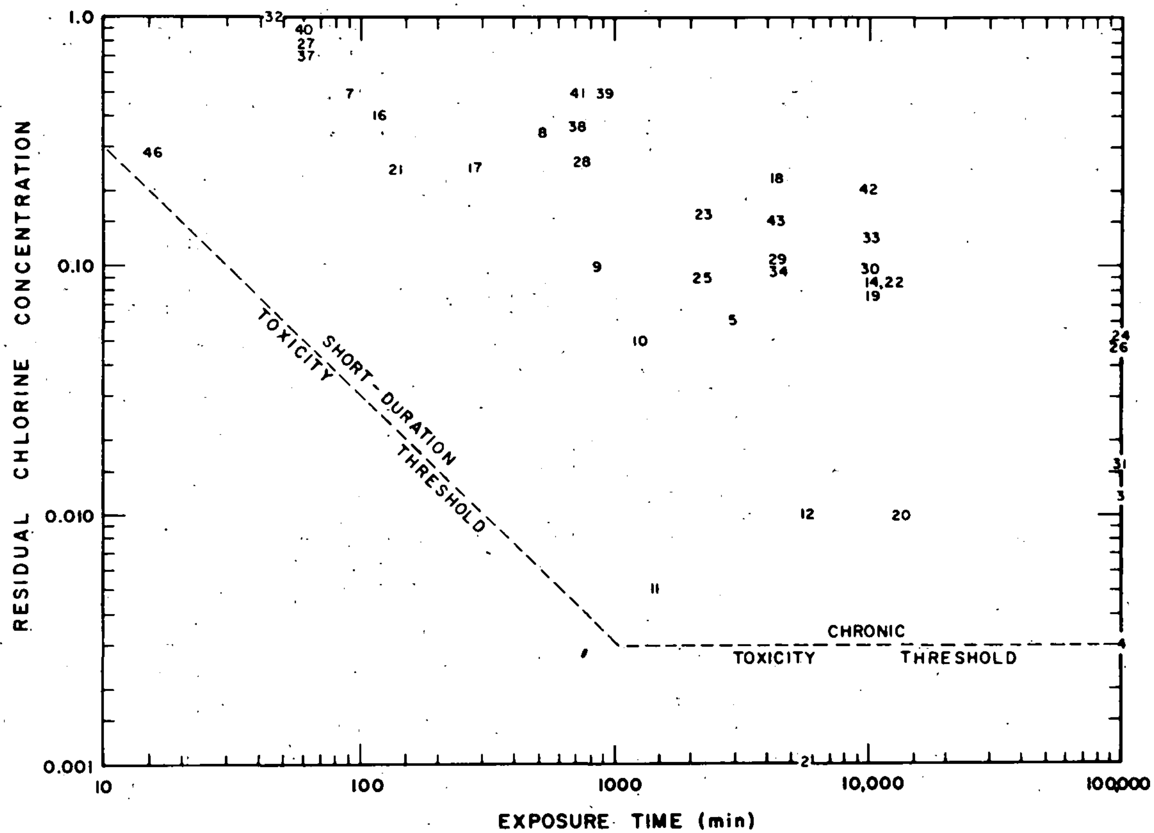

Fig. V-2. Summary of Residual Chlorine Toxicity Data. Numbers Refer to Toxicity Endpoints That are Identified as to Species of Organism, Effect Endpoint, and Reference in Table V-2. The Toxicity Thresholds Have Been Estimated by the Staff from the Trend in Published Data.

TABLE V-2

KEY TO FIG. V-2. EXPOSURES OF AQUATIC ORGANISMS TO TOTAL RESIDUAL CHLORINE. ALL CONCENTRATIONS WERE MEASURED.

Species	No.	Effect endpoint[(a)]	Reference
Protozoa	1	Lethal	Hale, 1930[114]
Cladoceran	2	Lethal (4 days)	Biesinger, 1971[115]
Scud	3	Safe concentration	Arthur, 1971[116]
	4	Safe concentration	Arthur and Eaton, 1972[30]
Trout fry	5	Lethal (2 days)	Coventry, et al., 1935[117]
	6	Lethal (instantly)	Coventry, et al., 1935[117]
Brook trout	7	Median mortality (90 min)	Pyle, 1960[118]
	8	Mean survival time (8.7 hr)	Dandy, 1967[119]
	9	Mean survival time (14.1 hr)	Dandy, 1967
	10	Mean survival time (20.9 hr)	Dandy, 1967
	11	Mean survival time (24 hr)	Dandy, 1967
	12	67% lethability (4 days)	Dandy, 1967
	13	Depressed activity	Dandy, 1967
	14	7-day TL50	Arthur, 1971[116]
	44	Not found in streams	Tsai, 1971[120]
Brown trout	45	Not found in streams	Tsai, 1971[120]
Fingerling rainbow trout	17	Lethal (4 to 5 hr)	Taylor and James, 1928[121]
Rainbow trout	15	Slight avoidance (10 min)	Sprague and Drury, 1969[31]
	16	Lethal (2 hr)	Taylor and James, 1928[121]

TABLE V-2 (cont'd)

Species	No.	Effect endpoint[a]	Reference
	18	96-hr TL50[a]	Basch, 1971[74]
	19	7-day TL50	Merkens, 1958[72]
	20	Lethal (12 days)	Sprague and Drury, 1969[31]
Chinook slamon	21	First death (2.2 hr)	Holland, et al., 1960[122]
Coho salmon	22	7-day TL50	Arthur, 1971[116]
	23	100% kill (1-2 days)	Holland, et al., 1960[122]
	24	Maximum non-lethal	Holland, et al., 1960
Pink salmon	25	100% kill (1-2 days)	Holland, et al., 1960
	26	Maximum non-lethal	Holland, et al., 1960
Fathead minnow	27	TL50 (1 hr)	Arthur, 1972[123]
	28	TL50 (12 hr)	Arthur, 1972[123]
	29	96-hr TL50	Zillich, 1969 a,b,c[73]
	30	7-day TL50	Arthur, 1971[116]
	31	Safe concentration	Arthur and Eaton, 1972[30]
White sucker	32	Lethal (30-60 min)	Fobes, 1971[124]
	33	7-day TL50	Arthur, 1971[116]
Black bullhead	34	96-hr TL50	Arthur, 1971
Largemouth bass	35	7-day TL50	Arthur, 1971
	37	TL50 (1 hr)	Arthur, 1972[123]
	38	TL50 (12 hr)	Arthur, 1972[123]
Smallmouth bass	36	Not found in streams	Tsai, 1971[120]
	39	Median mortality (15 hr)	Pyle, 1960[118]
Yellow perch	40	TL50 (1 hr)	Arthur, 1972[123]
	41	TL50 (12 hr)	Arthur, 1972[123]
	42	7-day TL50	Arthur, 1971[116]
Walleye	43	7-day TL50	Arthur, 1971[116]
Miscellaneous	46	Initial kill (15 min)	Truchan, 1971[125]
	47	Erratic swimming (6 min)	Truchan, 1971[125]

(a) TL50 = median tolerance limit.

temperature excess (above ambient) of 0.085°F. The effective concentration for damage to aquatic life would depend upon the exposure duration, and would likely be above 0.0034 ppm.

Quantitative estimation of the environmental impact of chlorination depends upon precise definition of residual chlorine and the analytical method chosen to determine its concentration. Since neither of these points appears to have been stated explicitly by the applicant, they are discussed in Appendix III-1.

In view of the alternative systems that are currently available for removal of growths from condenser tubes, the use of chlorine in power plants can be avoided. However, the present state of completion of the Palisades facility can be avoided by installation of an alternative system at this time.

If chlorination of the once-through system is unavoidable at Palisades, the following procedures are required for the applicant to carry out in order to reduce its toxic effects: (1) chlorination at a frequency limited to one hour per month for a period not to exceed 30 minutes duration with a minimum of a 2-hour period before the chlorination treatment is started again, in accordance with the Michigan Water Resources Commission requirements, and (2) chlorination of each of the two condenser water inlet boxes independently, thereby producing a residual chlorine concentration in the discharge into the lake that will not exceed 0.5 ppm. EPA in Appendix also recommends reduced levels for intermittent use of chlorine.

(b) Boric Acid

Releases of boric acid (H_3BO_3) should not be detrimental to aquatic organisms in Lake Michigan, since toxic levels have been shown to be much greater than the estimated release level of 5 ppm from the present radwaste system at the Palisades Plant. The minimum lethal dose for minnows exposed to boric acid for six hours at 20°C was 18,000 to 19,000 ppm in distilled water and 19,000 to 19,500 ppm in hard water.[32-34] (In water, 1 mg/liter = 1 ppm on a weight basis.) Exposure of rainbow trout to 5,000 ppm of boric acid caused a slight darkening of the skin of the trout,[35] and immobilization and loss of equilibrium occurred in a few minutes when the trout were exposed to 80,000 ppm. However, after 30 minutes exposure to this concentration of boric acid, the trout recovered rapidly when transferred to clean fresh water. The 24-, 48-, and 96-hour median tolerable limits TL_m's of mosquitofish (Gambusia affinis) to boric acid were 18,000, 10,500, and 5,600 ppms, respectively.[36] These tests were conducted over a temperature range of 68 to 73.4°F (20 to 23°C) and a pH range of 5.4 to 7.3.

(5) Induced Circulation

The principal effect of induced currents at the Palisades Plant will be to intersect the probable shoreline movements of several adult and (more important) juvenile fishes, as discussed under the individual species in Appendix V-2 and later in this section. The shoreline location of the discharge assures that a maximum number of fish will be affected, both by the currents and by temperature changes. The combined result may be heavy predation on juveniles by larger fish residing further offshore. This effect could be substantially reduced by selection of an alternative discharge located at about the 10-foot depth contour, with the discharge conveyed by a buried pipeline beneath an otherwise natural beachline. Such a discharge would also enhance nearshore mixing, particularly during periods of the thermal bar in spring and fall. In fact, the warm discharge will maintain a dynamic miniature thermal bar throughout the winter, as the warm, nearshore plume mixes with cold ambient water and sinks at the artificial thermal bar; and it will speed formation and lakeward progression of the bar in the spring. These mixing effects have been further discussed under lake hydrology and thermal effluent dispersion in Chapter III.

(6) Radiation

(Radiation is treated separately in Section V.E)

b. Terrestrial Biota

Terrestrial impact of Plant operation may result from releases of small amounts of radioactive nuclides in low concentrations to the air. Radionuclide effects are discussed in Section V. . Terrestrial effects on birds and fowl resulting from thermal and chemical discharges on the psammo-littoral community are discussed below.

c. Aquatic Biota

The once-through cooling system operation affects the aquatic environment almost exclusively. Below are described the effects of thermal and chemical discharges and mechanical damage from impingement and entrainment on aquatic plant and animal biota.

(1) Plants

(a) Phytoplankton

The principal impact of the once-through cooling at Palisades on the phytoplankton will be death of some cells and inhibition of photosynthesis in other cells due to toxicity of chlorine. A small percentage of cells pumped through the Plant will be killed by mechanical disruption. There will be some thermal stimulation of growth and reproduction of algal cells in the plume (when there is no chlorination), but passage times through warmed areas will be too short for significant increase in plankton abundance or replacement of the normal species assemblage by nuisance forms. These conclusions are derived from the following analysis.

i. Thermal Effects

Temperature, whether by direct or indirect effect, is one of the principal controlling influences upon algal growth. The average growth rate of natural populations of algae is usually limited by light and temperature when there are sufficient quantities of mineral nutrients available. For example, the alga Asterionella formosa was capable of one cell division per day at 50°F and two divisions per day at a temperature of 68°F.[37] Under optimum growing conditions, some algae are capable of producing three generations per day.

One of the concerns about artificial temperature elevation is that phytoplankton organisms may be killed, thereby destroying the base of the lake's food chain. The lethal temperature for algae varies with the species and with the normal temperature from which the temperature increase is experienced. Most of the algal species studied have a lethal temperature in the range from 91°F to 113°F, with the majority being near 111°F.[38] Diatoms which require cool temperatures are generally most sensitive to temperature change and can withstand a temperature increase of only 18 F° above normal. No reduction in numbers or species of diatoms was observed in a power plant discharge when the relatively constant temperature of the outfall did not exceed 94.1°F.[38] Similar lack of change has been reported for thermal discharges from other power plants into Lake Michigan.[39]

A related concern about waste heat discharge has been that undesirable species such as blue-green algae may be favored over the more desired green algae and diatoms. The more heat-tolerant blue-green algae may be better able to survive and grow at high temperatures. Diatoms generally dominate the phytoplankton below 86°F.[38] From 86° to 94°F, green algae tend to be favored over the diatoms, and the rate of production and diversity of the population tends to be slightly reduced. Green algae are a very useful part of the ecosystem food chain.

Above 94° to 95°F, blue-green algae begin to be favored over the green algae.[38] This is generally viewed as undesirable for aquatic ecosystems because the blue-green algae are not utilized by many of the herbivores and tend to act as a bottleneck to the flow of energy to the rest of the food web. The little-used blue-green algae may accumulate in sufficient quantities to produce objectionable scums, the principal outward manifestation of eutrophication.

It seems unlikely that the Palisades Plant could kill the phytoplankton of Lake Michigan and induce a shift from desirable diatoms and green algae to undesirable blue-green algae, even in the immediate vicinity of the outfall. Lauer[39] reported that he had not found temperature increases to cause a discernible shift in species diversity or abundance of algal cells, even in the heated plumes, at any of the 10 operating power plants which he studied, including some on Lake Michigan. The literature contains very few instances where such efects on phytoplankton in waters receiving waste heat discharges have been discerned, even in instances where the capacity of the station and its consequent waste heat discharges are too large for a relatively small receiving body of water.

The low incidence of observed effect of waste heat discharge on phytoplankton populations appears to be due to a number of factors. Perhaps the most important factor is exposure time. In stations similar to the Palisades Plant, phytoplankters experienced temperature elevations as high as 5 to 6 F° (3C°) above ambient for no more than 1/2 hour, a relatively short time compared with the 8 or more hours required for algal cells to divide. Attached algal growths on the walls of discharge canals, rubble, and other fixed substrates near the mouths of discharge canals are most apt to experience such shifts in dominance because they are almost continually exposed to elevated temperature. At the Palisades Plant, the surface area so affected is very small, and any algal cells which break off and enter the lake would represent an extremely small fraction of the total algal productivity in the system.

Death of algal cells, however, is not easily recognized, and recent studies have measured photosynthesis, or the formation of new organic matter, to determine thermal effects. A number of investigators have found that photosynthesis rate is affected by temperature.[37] In temperate climates such as at Palisades, photosynthesis by the entire phytoplankton community is inhibited, since lake temperatures are less than optimal for photosynthesis during most of the year. During late summer, natural water temperatures may approach or exceed the optimum. An optimum temperature of about 86.9°F has been reported by investigators who have been careful to distinguish between thermal and chlorination effects at power plants.[39]

Thus, artifical temperature increases have the potential for increasing photosynthesis rates during the cooler seasons and inhibiting photosynthesis rates during the late summer when natural water temperatures are highest. A number of investigators[37] have measured the pattern of seasonal response to artificial temperature increase and demonstrated that the photosynthesis rate must be measured during all seasons in order to calculate for the net change from the natural rate. No evidence was found that this has been done adequately at any power plant. Therefore, the potential impact of the Palisades Plant (and of others being built or planned for the lake) cannot be adequately assessed with present knowledge regarding photosynthesis rate as a function of temperature.

Formation of organic matter also requires time. Studies of photosynthesis rates require suspension of algal cultures in bottles at constant elevated temperatures for at least 2 hours. This considerably exceeds the time (less than 1 minute) that natural populations would be exposed to the maximum temperature of the Palisades Plant thermal discharge, and it does not match the pattern of exposure to decreasing temperature experienced by phytoplankton during their passage through the thermal plume. Dilution of the cooling water in the Palisades thermal plume could be so rapid that any effect on organisms passing through would quickly become unmeasurable. The present outfall design does not maximize dilution, however, so that some increases in organic matter formation may be measurable in the 24 hours or so that a plume (under conditions of no wind or currents) may require to cool to about 2 F° above ambient. These increases should be insignificant under most lake conditions.

ii. Mechanical Damage

Mechanical damage is common to organisms that are pumped through power plants or through scientific collecting devices. Cell breakage may be due to abrasion or to rapid pressure changes. At present, such breakage is unpredictable.

Ayers *et al.*[40] observed a small decrease, about 15%, in numbers of phytoplankton during their passage through the cooling system of the Waukegan Power Plant on Lake Michigan. Since thermal damage would not destroy the carcasses, some type of mechanical destruction must have been responsible for loss of cells. Considering the 1-day generation times for most phytoplankton algae, this loss seems well within the capacity of the community to recover. Since proliferation of algae as a result of eutrophication is feared in southern Lake Michigan, any small detriment to such proliferation might be welcome.

iii. Chemical Effects

Mortality of phytoplankton resulting from organisms passing through cooling systems (or loss of their ability to photosynthesize) have recently been attributed to toxic chemicals rather than to heat or mechanical damage.[41] Chlorine is used in many generating facilities to rid the cooling water piping of bacteria, fungi, and algae. These treatments are generally periodic "slugs" of high concentration (perhaps once a day, depending upon the power station). The treatments affect natural communities that pass through the station as well as the target organisms that lodge there.

Operating plans for the Palisades Plant call for periodic application of chlorine to the cooling water. The residual chlorine at the discharge will not exceed 0.5 ppm. The length of treatment will be limited to one hour per month. With the relatively clean water supply available at the Palisades site, a cleaning process to remove surface-adhering materials should not be required except at very infrequent intervals.

It can be presumed that the chlorine treatment will kill all organisms that pass through the cooling system during the treatment period. In addition, there may be toxic levels in the lake from the residual chlorine or its chemical byproducts. One could expect greater mortality of the sensitive diatoms and green algae from the chlorine added to the lake than of the tolerant blue-green algae, although this pertinent question has apparently not been addressed by researchers. Blue-green algae already constitute a nuisance in some areas of southern Lake Michigan.[42]

(b) Filamentous Algae

Since there is negligible bottom substrate suitable for its growth in the vicinity of the Palisades site, no impact of once-through cooling on filamentous algae (Cladophora) should result. Troublesome accumulations of detached masses are derived from other areas of the Lake. Currents induced by the Palisades Plant may reduce accumulations along the nearby beaches. These conclusions are derived from the following analysis.

Accumulations of filamentous algae (Cladophora and Spirogyra) have recently become a problem along beaches on the eastern shore of Lake Michigan, including South Haven (Fig. V-3),[42] but principally to the north in the Muskegon-Grand Haven and Traverse Bay areas.[43] Spirogyra was found by the Michigan Water Resources Commission to be abundant only north of South Haven. The principal filamentous algae near Palisades, then, is Cladophora glomerata. Detachment of large numbers of filaments of this normally attached algae causes them to become free-floating in the growing season. Windrows of algae broken from the bottom accumulate alongshore, and interfere with bathing. Rotting masses that settle become objectionable when they are bouyed to the surface by decomposition gases. Dead alewives accumulate with the algae, adding to the decomposition.

A principal factor in development of nuisance growths of attached algae is suitable hard substrate for attachment.[43] Cladophora requires a firm, stable substrate. It is often found at the waterline on breakwalls, boulders, and bedrock where wave action prevents the accumulation of sediments. The bottom near the Palisades Plant is notably deficient in such sediments, and is composed mostly of sand with some loose gravel.[13] The main hard surfaces during operation of the Palisades Plant will be the intake and outfall structures. Harder sediments are found along more northerly shores of Lake Michigan, where the algal problem now exists. Nuisance accumulations on beaches at South Haven are probably strands of algae grown many miles to the north or south (near nutrient-rich cities) and transported there by lake currents.

The southwestern shores of Lake Michigan are extensively colonized by Cladophora,[43] where heavy growths have been observed from Manitowoc to Kenosha; and growths near Chicago and Milwaukee have caused nuisance problems. The principal sources of Cladophora for beaches near Palisades may be drift from other areas. The bottom at Palisades for Cladophora growths should be surveyed to clarify the origin of these organisms. Such surveys at the Cook Power Plant site about 30 miles south have shown no growing Cladophora,, but some rotting plant material has been seen in depressions. Where suitable bottom materials exist for attachment, a two-cycle growth pattern (in the summer and the fall) has been recognized and reported by many observers.[43,45-48] The biology of Cladophora in fresh waters has been reviewed in detail by Whitton.[49] Factors affecting its growth include the time of the year and water temperature differences which affect rates of metabolic activity. Rapid growth begins in June, and by mid-July filaments have attained a size of 12-15 cm. The plants remain at this size until

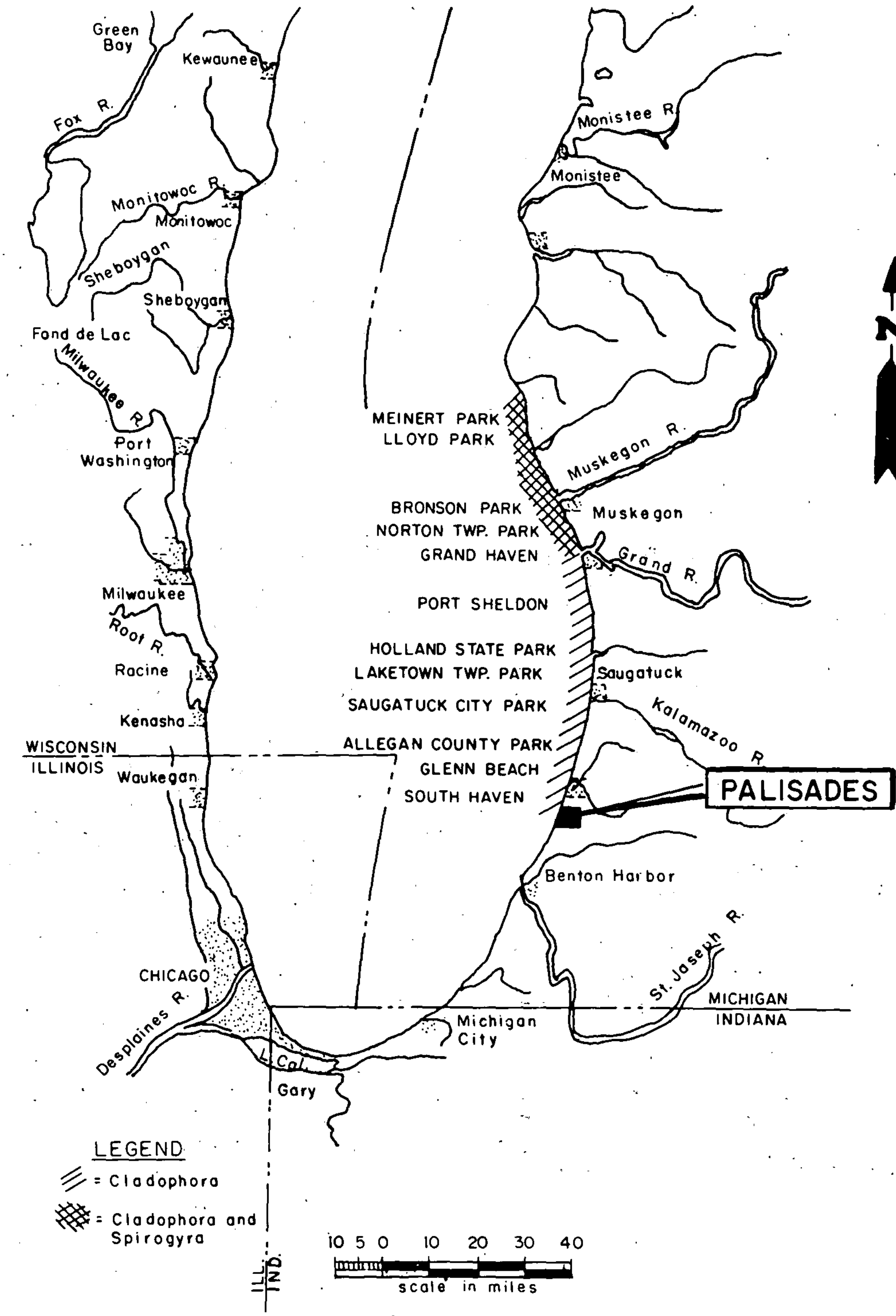

Fig. V-3

AREAS IN SOUTHEASTERN LAKE MICHIGAN AFFECTED BY NUISANCE ALGAE

(Ref. 42)

the end of July or early August, when renewed growth of the filaments initiates the second cycle. Growth continues rapidly until the filaments reach a size of 22-25 cm in late September and early October, at which time they are easily broken in rough water and become free-floating. Although Cladophora glomerata grows vigorously at temperatures in the range of 45 to 59°F,[51] it grows best at 68° to 77°F.[47] In waters in that temperature range, Waern[50] observed the colonization and establishment of a belt of C. glomerata within a 1-month period on bare surfaces. Cladophora appears to be sensitive to temperatures higher than about 77°F, which probably accounts for the growth lag in summer.[49] The accelerated growth of the second period (end of July or early August) has been ascribed to the germination of summer zoospores and other explanations.

Also related to the water temperature differences are the dominance patterns exhibited by Cladophora and other attached algae. Diatoms and Ulothrix metabolize better at colder temperatures[47] and have found to be dominant plants along the Milwaukee breakwall until the end of June.[43] A gradual increase in Cladophora growth occurred as the temperature rose, until by mid-July it was the dominant alga. As the water cooled, Ulothrix again became dominant. McNaught[47] observed this same pattern between Ulothrix and Cladophora beginning at earlier dates in Lake Mendota.

Other physical factors also play a role in the growth and development of Cladophora glomerata. Cladophora generally grows best where there is an unrestricted water flow. Soderstrom[46] and Van den Hoek[45] found that this species needs a high light intensity for its development, along with a pH range from 7.5 to 8.5. These conditions offer no barrier to extensive growth in Lake Michigan.

Lack of phosphorus and nitrogen is generally considered to be the main limiting factor to uncontrolled growths of algae in natural bodies of water. These elements are added to water as nitrates and phosphates by the breakdown of many compounds such as detergents, municipal wastes and soil runoff. Concentrations of 0.3 ppm for inorganic nitrogen and 0.03 ppm for phosphates are generally accepted as the critical concentrations, if all other conditions remain favorable for the growth of algae. These respective concentrations are often exceeded by effluent from municipal sewers, and many areas in the Great Lakes exhibit growth of Cladophora associated with these outfalls.[51] Herbst[43] concluded that availability of these nutrients is the reason for the increase to problem proportions of Cladophora in the Milwaukee area (which he studied in detail) and the Great Lakes as a whole.

Since the proper physical habitat for this nuisance species of attached algae is not found at Palisades, there seems little possibility that temperature increases or changes in current patterns could stimulate their growth in their normal habitat. Any such growths found in the vicinity of the Palisades Plant, which could be a nuisance at the bathing beaches, would therefore come from some source other than Palisades Plant operation. Temperature increases could affect the floating masses derived from elsewhere, however, although this has apparently not been studied in Lake Michigan. For example, warmer water at the beaches near the Palisades Plant might slightly stimulate the rate of decomposition to assist in clearing the beaches, or to make the decomposition all the more offensive. Considering that the stranded masses are heated by the sun, the extra few degrees imparted by the thermal plume will have insignificant effect. It is unlikely that floating masses would be stimulated to proliferate in the thermal plume, since Whitton[49] reported that fragments required 21 to 26 hours to double their fresh weight at 68°F. Floating _Cladophora_ would pass through the Palisades plume in a few hours at most. The currents induced by the thermal discharge could assist in keeping the _Cladophora_ masses away from the beaches, as observed by Storer (J. Storer, State University of N. Y. at Buffalo) in Lake Ontario. Instead of being blown upon the beaches by winds, the _Cladophora_ would be pushed lakeward as it drifted either north or south past Palisades. Once the windrows are in the open water, they would probably travel many miles before they would again be forced upon the shore.

(c) Vascular Aquatic Plants

There are no vascular aquatic plants in Lake Michigan near Palisades, according to all available references, including scuba diver surveys at the Cook site 30 miles to the south.[40] Such plants abound in relatively quiescent, shallow water environments rather than the turbulent wave zone that characterizes Palisades.

(2) Animals

(a) Benthic Invertebrates

The benthic invertebrate fauna in Lake Michigan have been well characterized in several studies since the 1930's.[52-56] Near the Palisades Plant, the benthic invertebrates were surveyed over a 2-year period by the applicant's consultants (see Appendix II-1, Table 4 for species list of benthic macro-invertebrates collected in this area).[1] Bottom samples were collected at 21 stations over a fan-shaped area within a radius of 5 miles from the Palisades Plant (Fig. V-4). Preoperational sampling was first conducted in May 1968, and continued through October 1970, although most samples were collected during the summer months. Since most benthic species are sessile organisms, they are good indicators of environmental impact[57] which may result from the thermal and chemical discharges at the Palisades Plant. The benthic invertebrates are typical of those found in Lake Michigan, with the major taxonomic group being amphiods (primarily Pontoporeia sp.), aquatic earthworms (Oligochaeta), freshwater clams (Sphaeriidae), aquatic insects (primarily Chironomidae), flatworms (Turbellaria), leeches (Hirundinea), and hydra (Coelenterata).

The density and species composition of benthic invertebrate communities in Lake Michigan depend on several factors, including bottom type (gravel, sand, silt, etc.), amount of organic matter which is a food source for benthic invertebrates on the lake bottom, water depth, and degree of organic enrichment from municipal and industrial effluents entering the lake.[58] A wave-washed zone that is practically devoid of benthic invertebrate species exists close to shore[56,59] and extends approximately 1 mile offshore.[60] This less productive zone has very few species and low densities of benthos, because of the disturbance of the sand bottom by wave action in shallow waters. As water depth increases away from shore and the bottom becomes stabilized and free of wave action, both the number of species and their densities increase (Fig. V-5). The increase in density away from shore of two major groups of benthic invertebrates found in the area of the Palisades Plant is shown in Figs. V-6 and V-7.

i. Thermal Effects

Potential effects of the thermal discharges on benthic invertebrates near the Palisades Plant are (1) direct lethal effects, and (2) sublethal effects resulting in species changes or population changes of selected species. Since the intake structure for the once-through cooling system is 6 feet above the lake bottom, entrainment of benthic invertebrates will be negligible. Some species of crustaceans that migrate vertically, such as Mysis sp.,[60] may be entrained, but the total numbers will be small compared with the total benthic community. In addition, preoperational sampling data showed that Mysis sp. was not abundant near the Palisades Plant.[61]

The impact of the heated discharge of 25F° above ambient when the Plant is at full power will depend on dispersion and mixing of the thermal plume in the lake. However, dispersion of the thermal plume

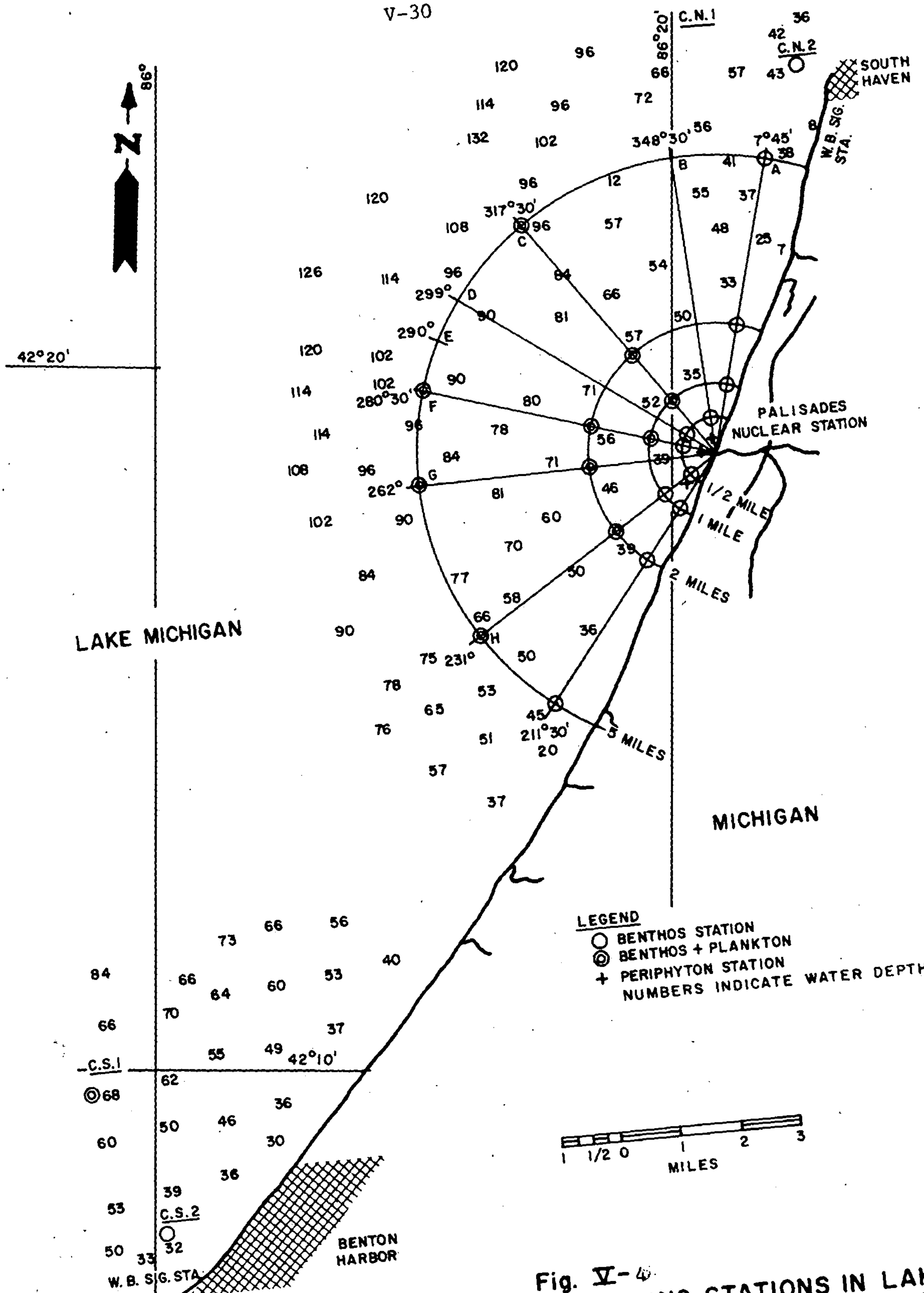

Fig. V-4

LOCATIONS OF BIOLOGICAL SAMPLING STATIONS IN LAKE MICHIGAN IN THE AREA OF THE PALISADES PLANT SITE
(Ref.61)

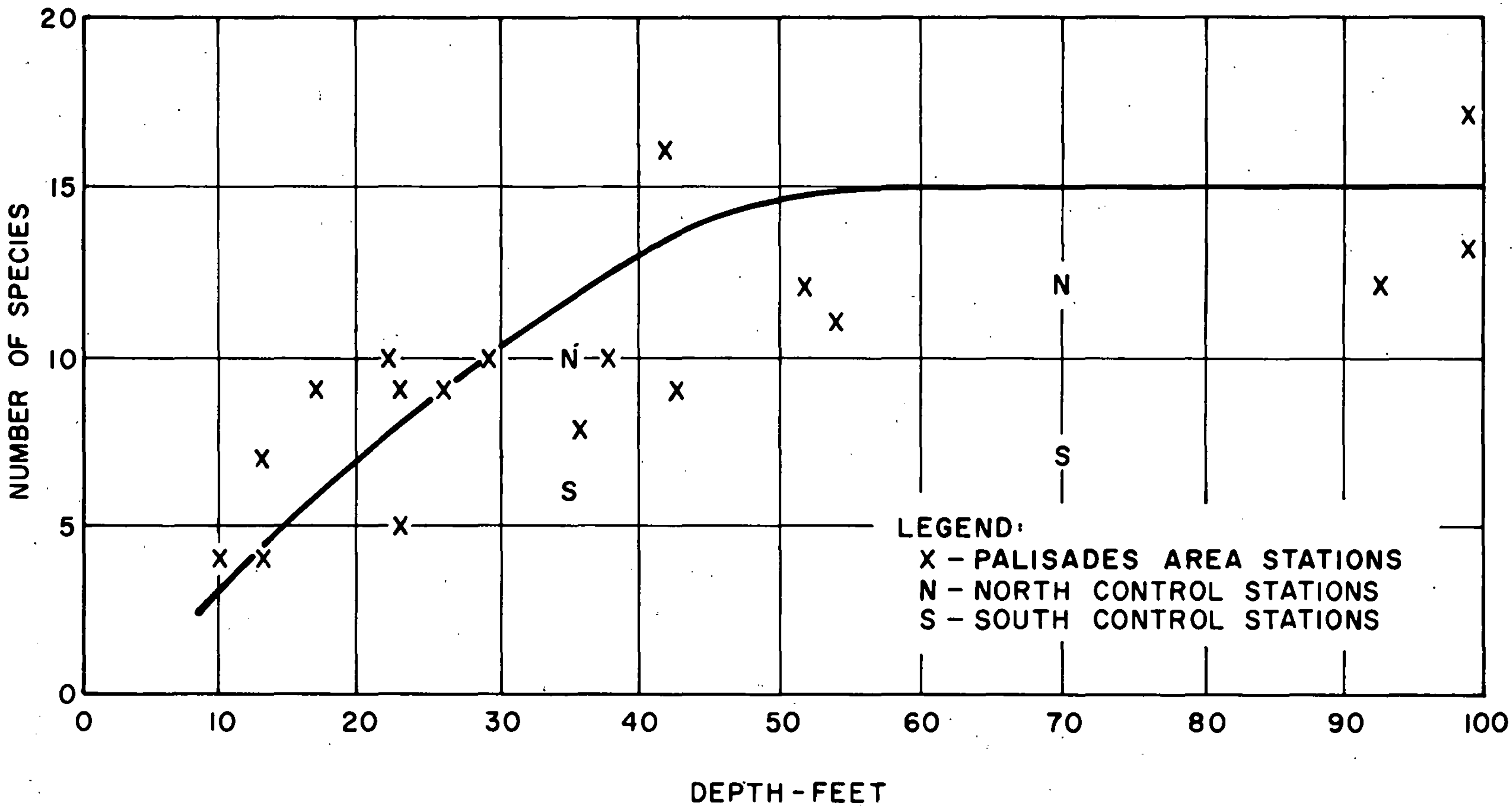

Fig. V-5
Number of Species of Benthic Invertebrates Plotted Against Water Depth of Lake Michigan in the Area of the Palisades Plant Site. Samples Were Collected in August, 1968. Data from Reynolds and Swarts (Ref. 66).

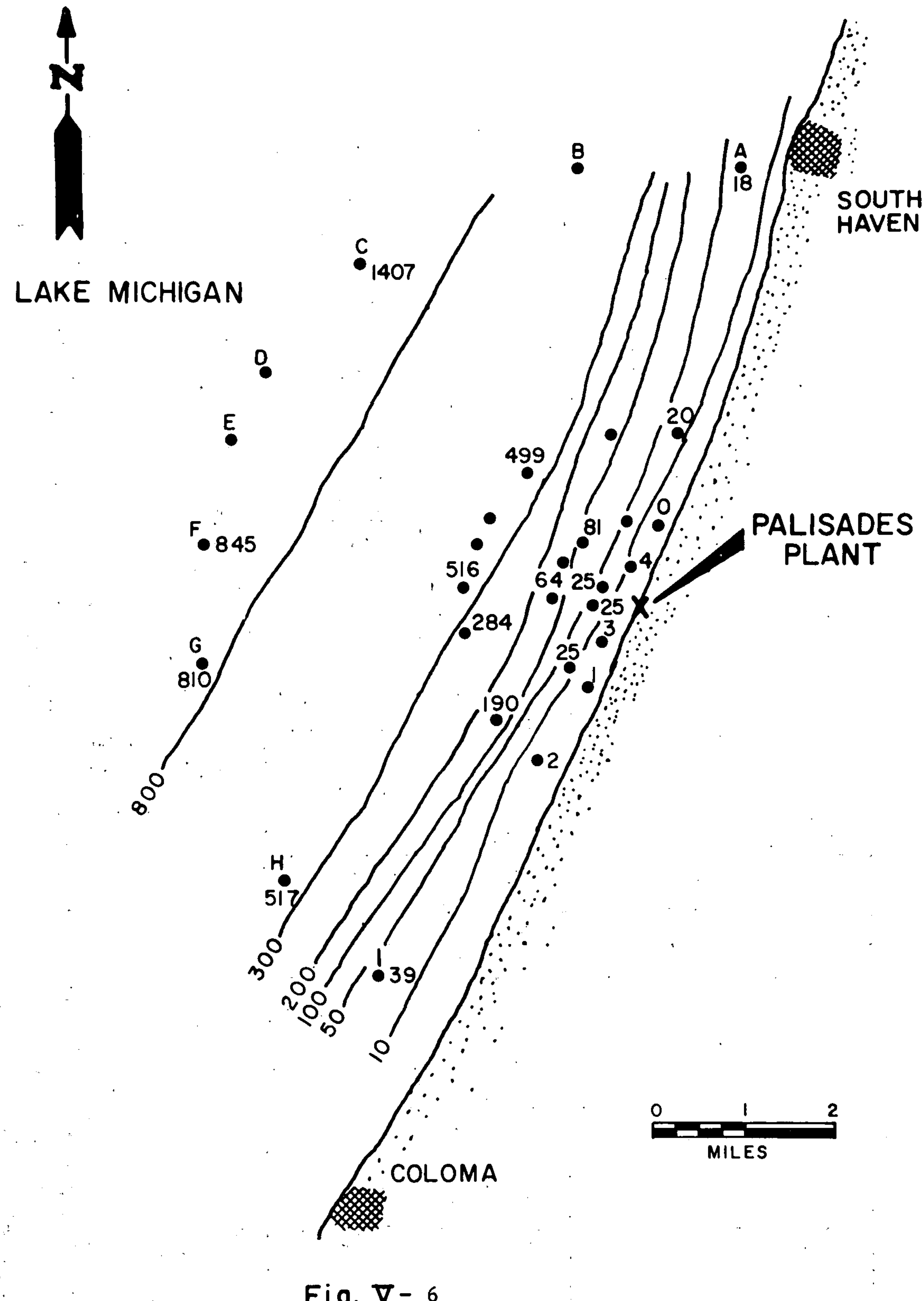

Fig. V- 6
DENSITY ISOPHENES (numbers / ft^2) OF BENTHIC AMPHIPODS IN LAKE MICHIGAN IN THE AREA OF THE PALISADES PLANT SITE. SAMPLES WERE COLLECTED IN AUGUST, 1968. DATA FROM REYNOLDS AND SWARTS. (Ref. 66)

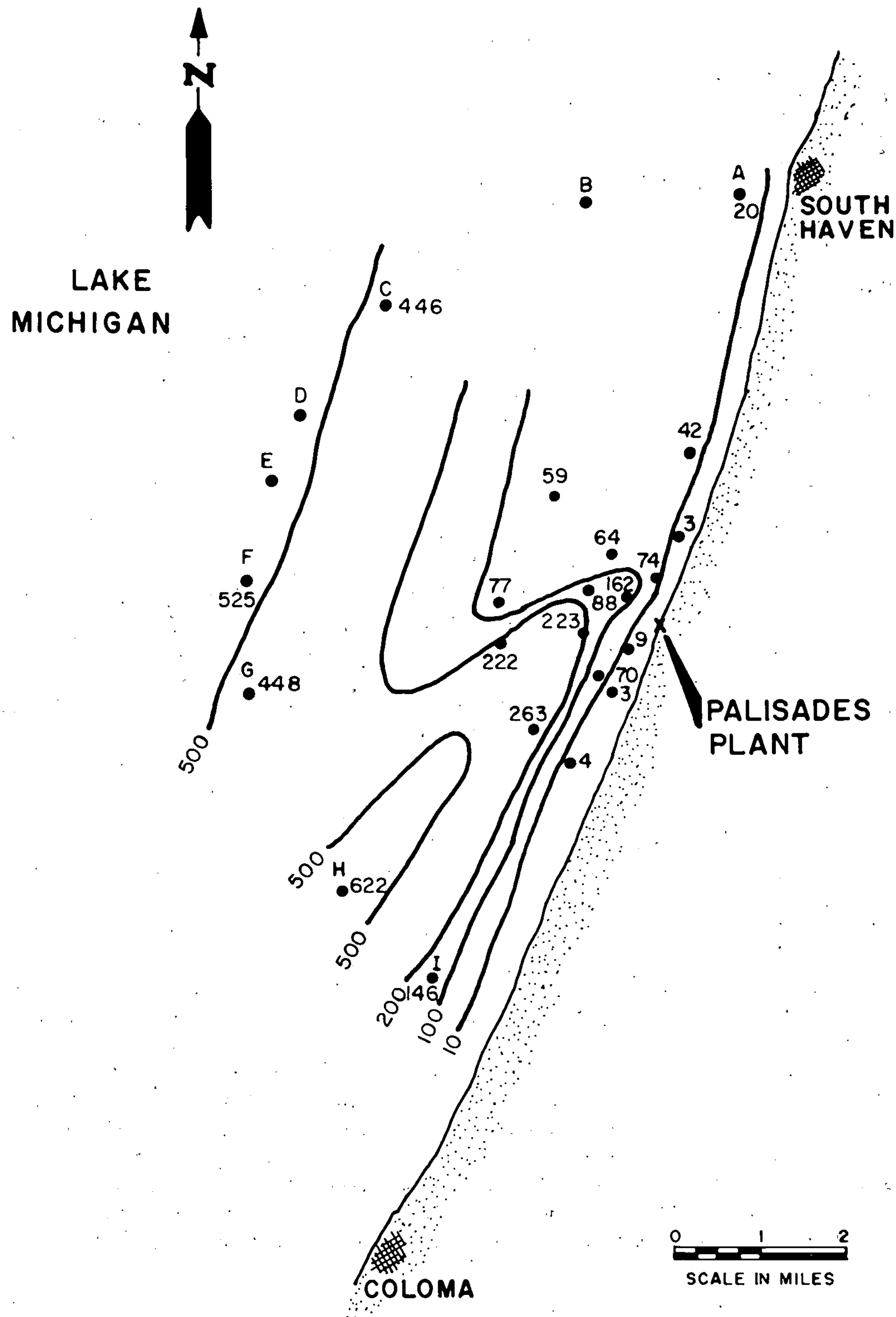

Fig. V- 7
DENSITY ISOPHENES (numbers / ft.^{2}) OF AQUATIC OLIGOCHAETES IN LAKE MICHIGAN IN THE AREA OF THE PALISADES PLANT SITE. SAMPLES WERE COLLECTED IN AUGUST, 1968. DATA FROM REYNOLDS AND SWARTS (Ref. 66)

is dependent on wind directions and currents. Over 54% of the time the plume will be alongshore (parallel to shore). (See Section II.E for a description of the lake hydrology in this area and Section III.D for plume dispersion from model studies). Current conditions, discharge velocities, and thermal rise across the condensers were variables in the alongshore current model developed by Argonne National Laboratory[62] for determining the dispersion and mixing of thermal plumes in the lake. During periods of alongshore currents, this model predicts that the plume will follow the current. The 1F° isotherm above ambient lake temperature will be confined within 600 feet along the shore; about 12 miles down the shore it will disperse and no longer be detectable (see Section III.D for a description of plume dispersion). Also, mixing will be relatively complete so that there will be negligible vertical stratification of the thermal plume. Thus, over 54% of the time, the thermal plume will be confined to a relatively small shore area which is in the sterile zone of benthic invertebrates in this area of Lake Michigan.

In the case of no lake current (6% of the time) and offshore currents (40% of the time), the 1F° excess isotherm will extend about 2.5 miles directly offshore and will cover an area of approximately 900 acres. Since this water is less dense, the thermal plume will stratify on the surface and therefore will not be in contact with the lake bottom. Thus, it should not affect the benthic invertebrates on the bottom of the lake near the Palisades site.

The benthic invertebrates around the thermal outfalls of several operating power plants on Lake Michigan have been studied in order to determine the impact of thermal discharges on them. Studies of the benthos were conducted by the Michigan Department of Natural Resources[63] near the thermal discharge of the J. H. Campbell Generating Station, a 647-MW coal-fired plant 1/2 mile inland near West Olive, Michigan. The plant produces a maximum temperature rise in cooling water of 17F° (9C°), which partially cools in a 5/8-mile long canal before it enters Lake Michigan. Benthic samples were collected at five transects running perpendicular to shore: at the thermal outfall of the plant, 1/2 mile north and south of the outfall, and 3 miles north and south of the outfall. The temperature rise of the Campbell Plant during the August survey was 14F° (7.8C°). Results of this survey showed a significantly greater number of species per unit area of lake bottom in the transect at the thermal outfall when compared with the control stations located north and south of the outfall. However, the total number of individuals per unit area was not significantly greater. It is difficult to assess the reason for the increased number of species, most of which were crustaceans and aquatic Diptera (Chironomidae), since there did not appear to be a decrease in numbers of individuals of the other species that were collected at the control stations. It suggests that the additional species at the thermal-outfall transect were due to organic enrichment present in the water of the Pigeon River that is circulated through the plant. Similar increases of species numbers at thermal outfalls in Lake Michigan were reported by Seeburger[64] and Beer and Pipes.[15]

Krezoski[67] studied the benthic fauna around four power plants on Lake Michigan: the Campbell Plant, the B. C. Cobb Plant, the Big Rock Point Nuclear Plant, and the Port Washington Plant. He reported a slightly decreased number of benthic invertebrates close to the discharge structures of these four plants, and concluded that this was due to current scour rather than a thermal effect. Some current scour will probably be observed near the Palisades Plant, since the discharge will flow in shallow water at a velocity of 2 fps. Any effect on benthic invertebrates from thermal discharges will be localized in the immediate area of the outfall and will have negligible impact on the overall benthic populations, since the density of benthos close to shore is very low. In fact, immediately adjacent to shore, the density is zero for many species such as amphipods and oligochaetes (see Figs. V-6 and V-7).

ii. Chemical Effects

Among the chemicals to be released from the Palisades Plant, the most detrimental to benthic invertebrate life may be chlorine and its compounds such as chloramines. Arthur and Eaton[30] found 19-hour survival of half of a population at 0.22 ppm; reproduction was reduced when the concentration was maintained for 15 weeks at 0.0034 ppm. The 0.5 ppm of residual chlorine in the discharge (1 hour per month) will result in toxic levels for benthic invertebrates that are in the vicinity of the outfall. Two factors will reduce its effect at greater distances; (1) the chlorine demand (i.e. other organic material that is present) and (2) the degree of dilution of chlorine that reaches the benthos.

(b) Psammo-Littoral Community

In the wet zone of sandy beaches of lakes exists an interesting community of organisms known as the psammon which lives in the water-filled interstices of the sand.[67] Typically, this is a diverse community consisting of rotifers, flatworms, roundworms (nematodes), and immature stages of other organisms such as insect larvae.[68,69] The community occupies a habitat intermediate between the dry beach - inland soil communities and the aquatic communities. The width of the zone in which these organisms are able to live depends on the lake level and water movement.

Algal flora growing on the sand and organic detritus washed onto the beach by wave action provide the food sources for the psammon community. In turn, psammon often provide food for shore birds feeding in the wet-beach zone.

The use of the wet beach zone of Lake Michigan as a feeding and rest area by shore birds such as sandpipers, killdeer, yellow-legs, etc., suggests that the psammon community is an important food source for these shore bird species. Thus, the psammo-littoral community may be an important component in the Lake Michigan ecosystem and one which must be considered in assessing potential impacts from operation of the Palisades Plant.

Since it is the near-shore waters which provide the water for the psammon, any deterioration of the beach-zone waters could affect it. The effluent from the Palisades Plant will disperse along the shallow beach zone when there are alongshore currents (see Section III.D for a description of thermal plume dispersion), and the heated water and chemicals added to the effluent will thus contact the psammon community. Because of the lack of data on the sensitivity of this community to thermal and chemical conditions, it is difficult to assess the impact of Plant operation on the psammon in the area of the Palisades site. Considering the predicted rapid loss of heat to the atmosphere, and plume dispersion, however, the area of severe thermal impact from the plume on the beach-zone community will be small, covering a relatively small area of beach to the north and south of the Plant.

The impact of chemicals such as chlorine on the psammon, however, may be more severe in light of the sensitivity of some invertebrate species to sublethal concentrations, as previously discussed. If toxic levels of chlorine to psammon species persisted as far as a few miles along the beach, this would have an adverse impact on the Lake Michigan ecosystem including onshore birds utilizing the psammon community as a food source. In addition, maintenance of natural communities of aquatic organisms is considered important and necessary when the specific role of these species is unknown. However, there may be some impact on the little studied psammo-littoral community but this cannot be predicted with present knowledge.

(c) Zooplankton

Zooplankton organisms will be pumped through the Plant cooling system, and some of them will likely be killed by mechanical abrasion, pressure changes, thermal shock, chlorination, or a combination of factors. Limited evidence now available suggests that about 30% of the organisms drawn into the turbine condenser flow (390,000 gpm) may be killed, as well as all organisms entering the service water flow (15,000 gpm). At apparent maximum densities of zooplankton in lake water in June of about 5.7 organisms per gallon,[44] the Palisades Plant may kill 11.1 billion zooplankton organisms per day out of 34.2 billion drawn into the Plant. Most of the organisms so destroyed would enter the food chain as organic debris and thus would not be lost to the lake ecosystem. Generations of most zooplankton organisms are short and the unaffected stocks in the lake may be large enough for repopulation to occur within a few days, although there may be changes of species associated with greater mortality of some forms. The present limited information on zooplankton damage during entrainment in cooling water generally, and the lack of adequate understanding of zooplankton composition or community dynamics at Palisades in particular, do not allow a precise judgment of the significance of impacts on zooplankton. The following considerations are important to this assessment.

It is unlikely that the abundance of zooplankton in the intake water will differ substantially from that in the lake water surrounding the intake. The abundance there probably varies seasonally and diurnally (as the organisms migrate vertically with a 24-hour period) although there are insufficient data available to confirm these common variations at Palisades. In addition to those organisms that are pumped, others will be entrained in the dilution water which mixes with the thermal plume dispersed in the lake.

The relative importance of the three principal impacts, thermal, mechanical, and chemical, on this group of organisms is not clearly understood. Coutant[14] has stated that laboratory data on survival times at elevated temperatures can be used to predict whether pumped organisms will survive the thermal shock. Unfortunately, thermal resistance data are not available for the species of zooplankton encountered at the Palisades site. Mechanical damage may be inferred from studies at existing power plants in which broken organisms have been collected in the discharge. Studies by Biotest Laboratories[15] at the Waukegan Plant (preliminary results obtained through D. S. Bryon, Region V, Environmental Protection

Agency) identified mortality of up to 30% in the passage through the plant in March, 1971 although contribution to deaths by thermal shock could not be separated. Use of a different pump raised the percentage mortality. In most cases, the larger zooplanktons such as Limnocalanus macrurus sustained the greatest mortality, often nearly 100%. Exposure to chlorine compounds prevents any survival of pumped organisms during the period of treatment, and likely affects many others in the lake. Patrick and McLean[70] found several estuarine zooplankton organisms to be extremely sensitive to 5-minute exposures to chlorinated water, with mortality in the range of 75 to 90%. The importance of this treatment would depend largely on its frequency. All organisms that enter the service water system during treatment can be presumed to be killed.

In the general absence of more detailed information, we must presume that at maximum zooplankton densities in June there will be an unavoidable loss of approximately 9.9 billion organisms per day in the turbine condenser flow (30% of 33 billion organisms per day) and 1.2 billion organisms per day in the service water flow (100% loss of organisms pumped). One can speculate that since generations of most zooplankton organisms are relatively short, and there are abundant supplies of unaffected organisms in the dilution water in the lake, losses may be recovered within a few days. The dead zooplankton will still enter the food chain, perhaps more rapidly than would live organisms that are capable of avoiding predators. Warmer temperatures in the plume may stimulate the growth and reproduction of the affected species (particularly those individuals not pumped through the Plant but entrained in dilution of the plume) to the point where the abundance at the downwind side of the power Plant may be increased. On the other hand, selective removal of larger species may change the species structure of the zooplankton. Precise predictions are simply not possible with available information.

(d) Fish

Impacts of the Palisades facility upon the 28 fish species identified near the site (details are presented in Appendix V-2) can be evaluated only by reference to the life histories of the individual species. Of principal importance are the conditions when certain fish are actually near the site. Most species have far-ranging annual movements associated with various life stages and processes, and seasonal lake temperatures. Temperature requirements are specific for each species and often for each life stage of any one species. Thus, it is pointless to dwell, for example, upon temperature influences on incubation of bloater eggs when this process occurs only at depths of 120-180 feet or more in southern Lake Michigan. On the other hand, it is important to recognize that while cisco are deep-water fish, the juveniles spend the first months of their life in the shallow near-shore waters where their alongshore movements bring them into direct contact with the Palisades thermal plume.

Brief summaries follow of the principal nonchemical impacts of once-through cooling on major fish species in the lake; schematic diagrams of annual movements of the fish are included. The detailed analyses with references are in Appendix V-2. The effects of chlorine and other chemicals on fish are discussed collectively at the end of this section.

i. Thermal and Mechanical Effects

The selection of species to discuss in detail has been a subjective judgment of "importance," tempered by limitations of time for analysis and availability of information. Fish populations in Lake Michigan have undergone drastic changes in the past 100 years due to human influences -- principally commercial fishing, penetration of the sea lamprey and alewife into the upper Great Lakes due to opening of the Welland Canal around Niagara Falls, and introduction of salmon -- and the changes have been documented by the staff of the Great Lakes Fishery Laboratory of the U. S. Bureau of Sport Fisheries and Wildlife and the State of Michigan Department of Natural Resources (see references in Appendix V-2). The regulatory staff believes that these chronicles of change identify the "important" fish species in the lake today, and offer a guide to species likely to experience impacts from the Palisades Plant.

The organization that follows considers, in turn, the alewife (especially abundant), four coregonid species (very important historically or currently and one species listed by the U. S. Department of Interior as "endangered"),[71] the salmonid species (important salmon and trout), perch and smelt (abundant at the site and important for fisheries), and two game and two forage (food) species that are abundant at the site.

[a] Alewife (*Alosa pseudoharengus*)

Movements of schools of juvenile and adult alewife along the shoreline of southeastern Lake Michigan in late spring and summer will be interrupted by the shoreline discharge (Fig. V-8). High temperatures may displace some fish from the immediate discharge area. Since alewife spawn in tributary streams, some may attempt to spawn in the discharge at a date earlier than normal. The small size of the discharge canal will prevent the number of premature spawners from becoming excessive. Annual die-offs of alewife in May and June (a recurring phenomenon) may be accelerated by a warmer thermal plume, or the currents may concentrate dying fish making them more visible. The overall impact of the thermal discharge on this species is not expected to constitute a significant degradation. Detailed discussion begins on page A-41.

[b] Lake Whitefish (*Coregonus clupeaformis*)

This species is close to the southern limit of its distribution at the Palisades site, and depends upon exceptionally cold winters for successful reproduction in the southern basin of Lake Michigan. Any heating of lake water in winter will likely reduce reproduction success, for spawning would be delayed and hatching advanced by several days. There is apparently no spawning near the Palisades Plant, and population of the southern basin is likely maintained by migration from the northern part of the lake. There is little biological reason to maintain optimum conditions for reproduction in the immediate Palisades area.

If reproduction occurred in the Palisades area (or if the area is designated for possible future reproduction), the principal impacts on the population would be (1) warming incubating eggs on the bottom in winter when the thermal plume sinks, and (2) interception of shoreline movements of juveniles by the discharge during the period May through July (Fig. V-9). There could be some mortality of juveniles due to the thermal shock of being drawn into the thermal plume with dilution water. The Palisades Plant thermal discharge may preclude use of this immediate area for future successful reproduction of the whitefish. The impact should not be major, however, if other shoreline areas are available, principally in the northern parts of the lake. Detailed discussion of this species begins on p. A-45.

[c] Cisco or Lake Herring (*Coregonus artedii*)

The principal impact of the thermal discharge on the cisco would likely be entrainment of juveniles in the plume during shoreline

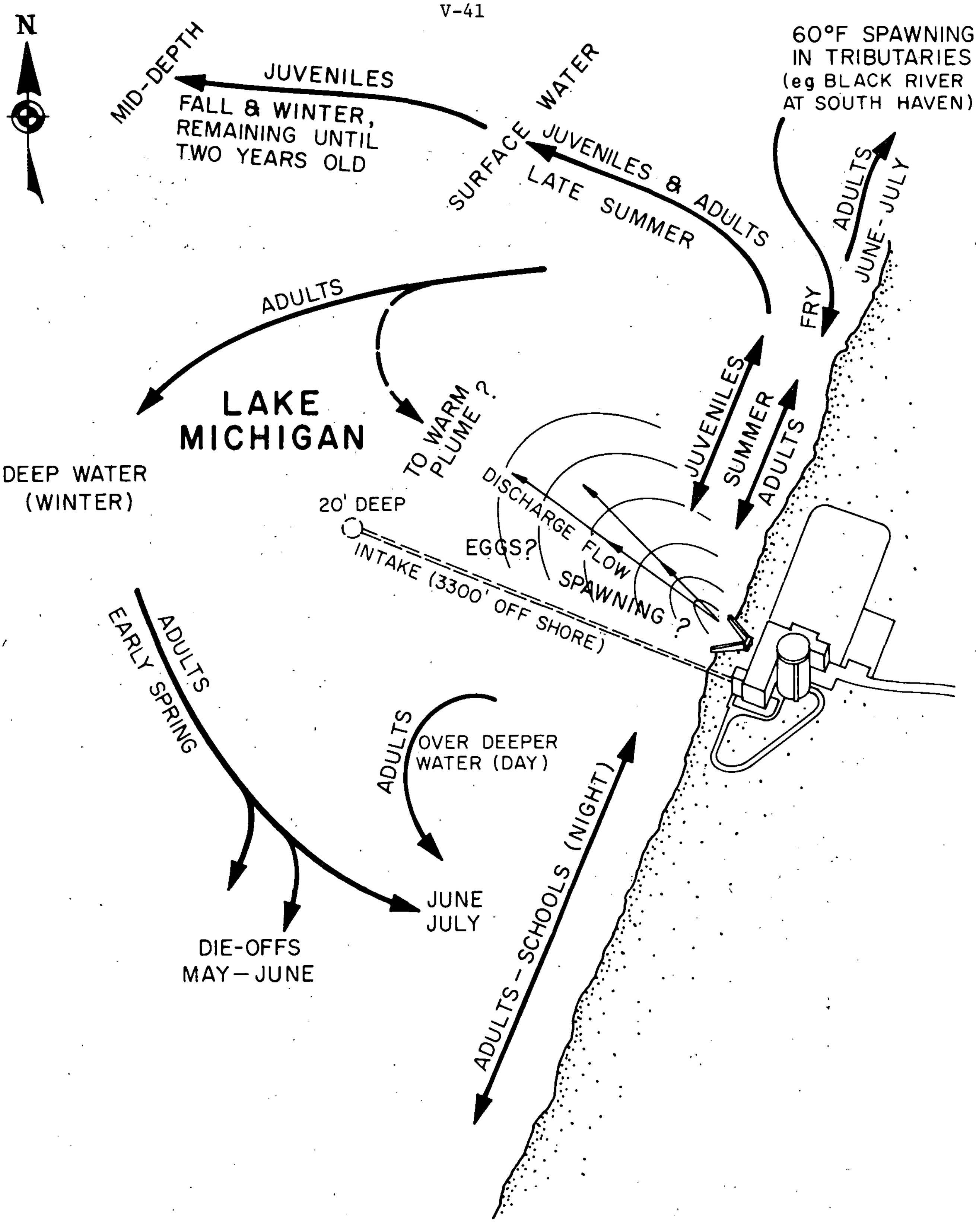

Fig. V - 8
SCHEMATIC DIAGRAM OF THE LIFE CYCLE OF THE ALEWIFE IN RELATION TO THE PALISADES PLANT

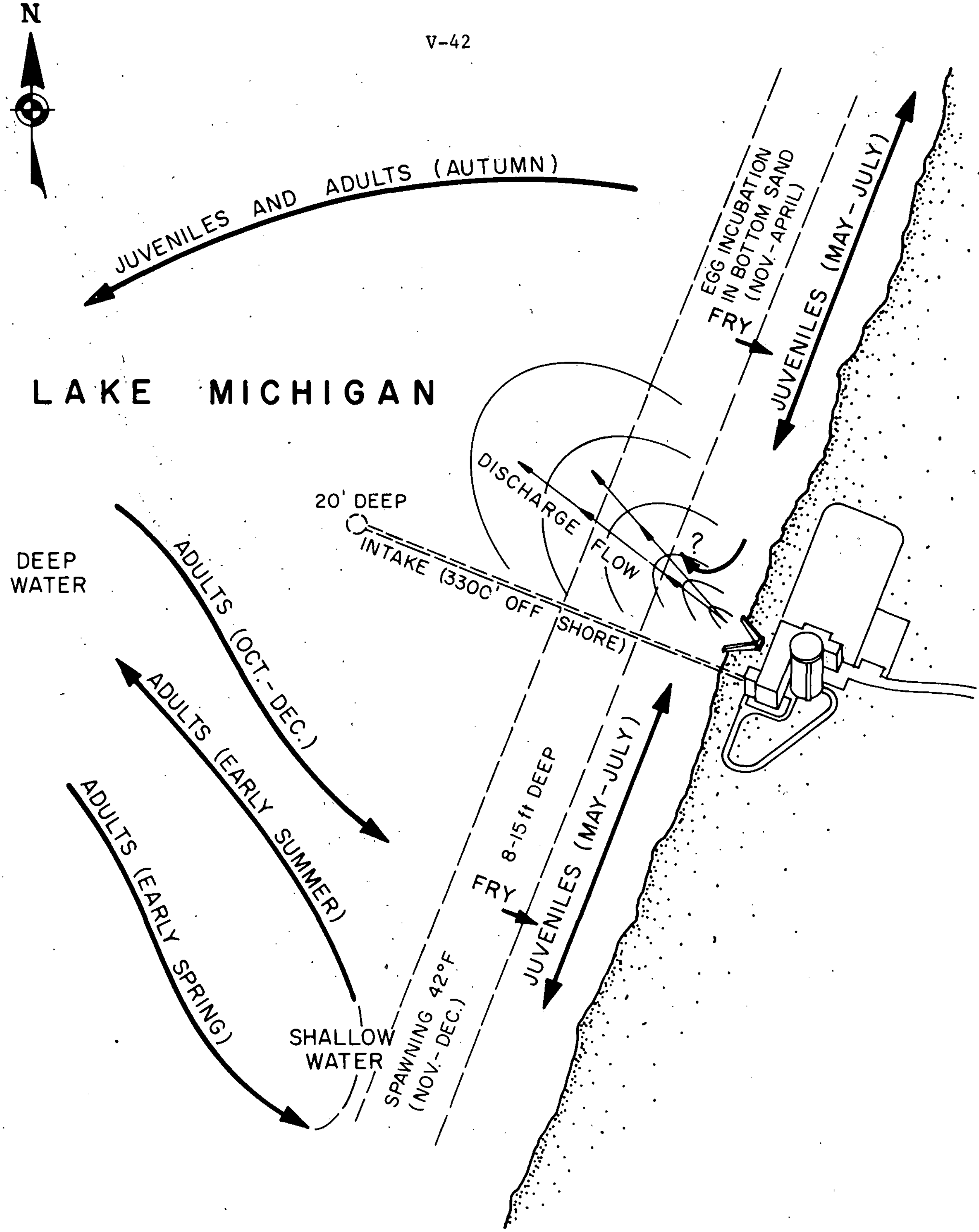

Fig V-9
SCHEMATIC DIAGRAM OF THE PROBABLE LIFE CYCLE OF THE LAKE WHITEFISH IN RELATION TO THE PALISADES PLANT

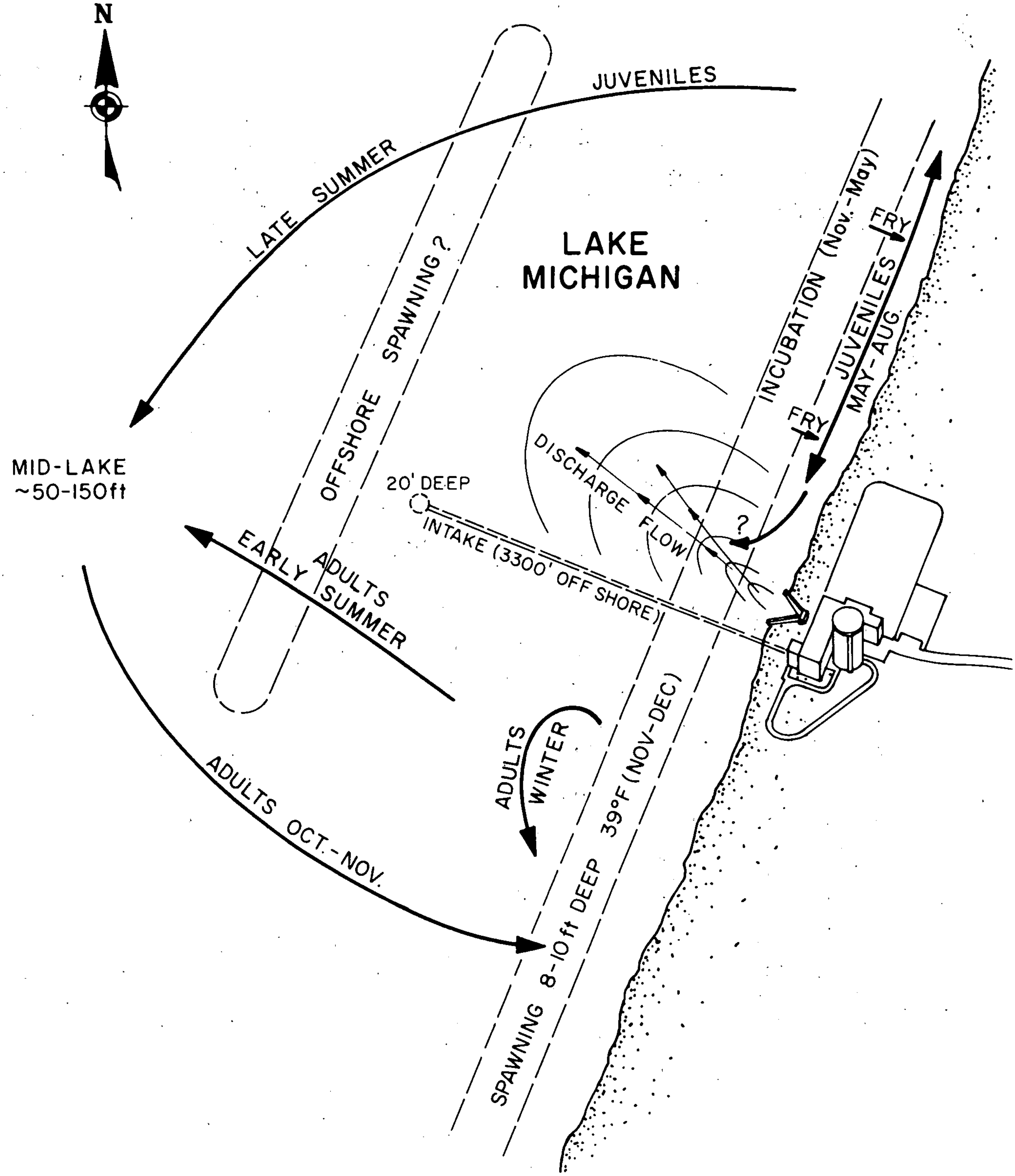

Fig. V-10
SCHEMATIC DIAGRAM OF LIFE CYCLE OF CISCO
IN RELATION TO THE PALISADES PLANT

movements from mid-spring through late summer (Fig. V-10). Water temperatures may be sufficiently high in the plume to cause some deaths due to thermal shock, unless the fish are able to avoid the plume (most likely when fish are larger in summer). The immediate impact will not be major for the lake since the species is currently not abundant in the Palisades area due to severe competition with the introduced alewife. The Palisades area does not appear to be an especially important site for re-establishment of the population, although present evidence is inadequate for precise judgment. Detailed analysis of this species begins on p. A-51.

[d] Bloater (Coregonus hoyi)

No impact is anticipated since all available evidence suggests that the species occurs only in deep water that will be unaffected by thermal discharges from Palisades into the lake (Fig. V-11). A more detailed analysis begins on page A-58.

[e] Endangered species: The longjaw cisco, Coregonus alpenae

In the United States, 101 species and subspecies of wildlife (14 mammals, 50 birds, 7 reptiles, 30 fish) are now threatened with extinction. Included in this list is the longjaw cisco, a species that formerly had been common in Lake Michigan.[71]

The endangered existence of C. alpenae is clearly related to different factors than temperature change or other influences likely to occur from the Palisades Plant, as is discussed in more detail beginning on page A-59. The principal influences have been the commercial fishery, the sea lamprey, and introgressive hybridization with other species.

[f] Coho Salmon (Oncorhynchus kisutch)

The principal impact appears to be from elevation of water temperatures near the mouth of the Black River in September to near-lethal levels when fish are concentrated there prior to spawning and are unlikely to attempt to avoid the warmer water. This would occur during strong onshore winds when the Palisades plume is pressed along the beach, and the 1F° excess isotherm may occur up to 12 miles away. The frequency of this occurring has not been estimated. The impact of some losses of fish or delay in entry into the Black River on survival of the species in Lake Michigan is not expected

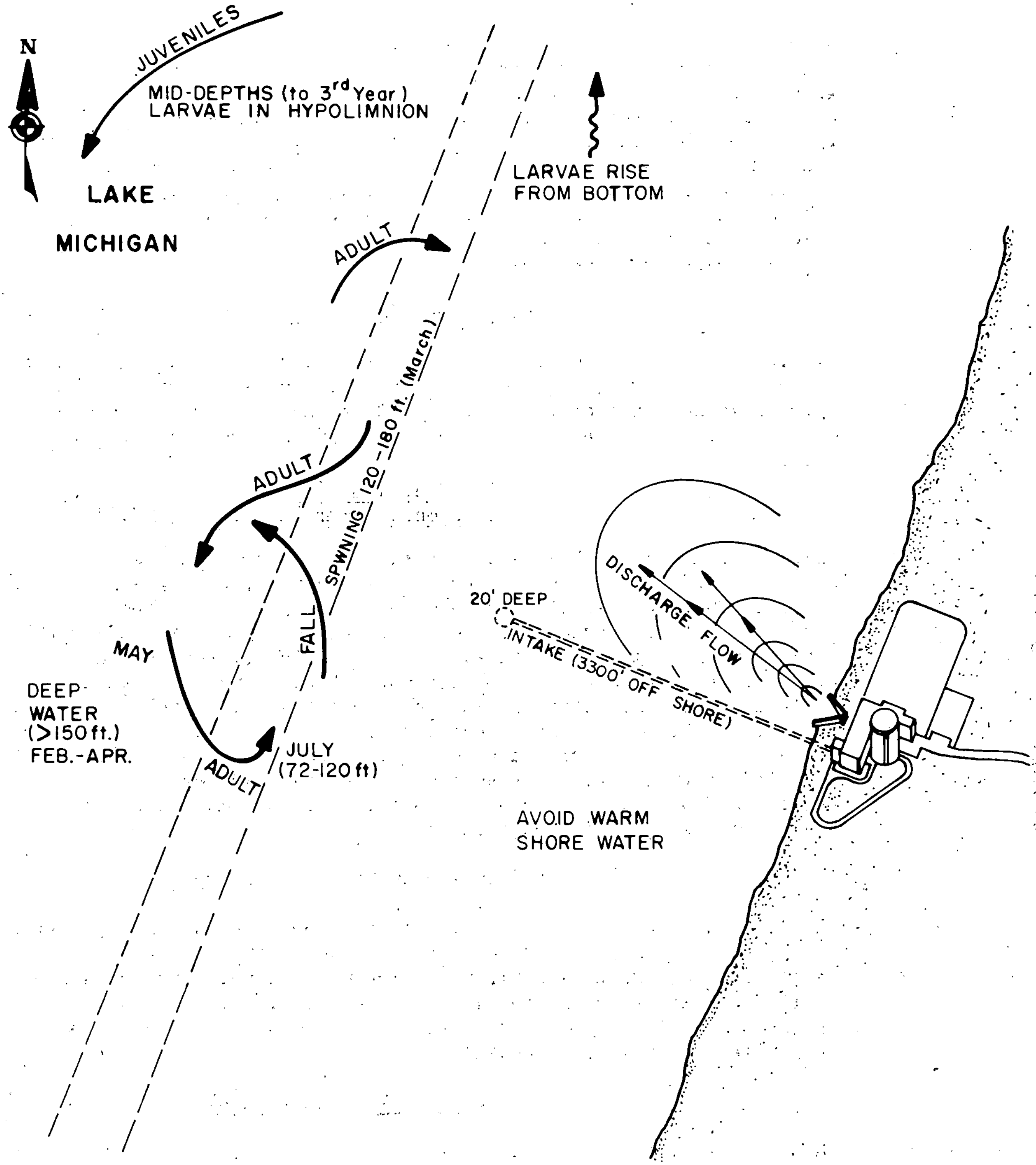

Fig. V- 11

SCHEMATIC DIAGRAM OF THE LIFE-CYCLE OF THE BLOATER IN RELATION TO THE PALISADES PLANT.

expected to be major, particularly since more salmon generally return to parent streams than are necessary to supply hatcheries with eggs. On the other hand, elevated temperatures may modify the availability of these adult fish to fishermen in the fall, a factor that cannot be assessed with available information. The warm thermal plume may hasten retreat of salmon to deeper water in the summer but attract them in early spring (as do tributaries). This may enhance the early spring fishing but shorten the fishing season in late spring by a few days (Fig. V-12). Detailed discussion of this species begins on page A-61.

[g] Chinook Salmon (Oncorhyncus tshawytscha)

Limited knowledge about this recently introduced species suggests that there will be no major impact from Palisades cooling water. The species is not stocked in the Black River, and thermal influences will be trivial at the St. Joseph River. See page A-62 for more details.

[h] Lake Trout (Salvelinus namaycush)

Experimental fishing by the U.S. Bureau of Sport Fisheries and Wild-life conducted after preparation of the Draft Detailed Statement suggests that this species may now be spawning in large numbers along the entire southeastern shore of Lake Michigan, including the area near the Palisades intake. Stratification of the thermal plume at the surface will probably not retard spawning in the fall (although this should be examined carefully) but the sinking plume in winter will subject the incubating eggs to abnormally warm temperatures periodically and induce premature hatching. The severity of this effect for successful reproduction cannot be established with available data. Additional information is presented in the Appendix V-2, page 63.

[i] Steelhead Trout (Salmo gairndneri)

Steelhead will be attracted to the current patterns at the discharge during seasons when temperatures do not exceed about 70°F. This should provide additional fishing. The warm temperatures of summer will cause fish to avoid the immediate area. The impact may, on balance, be favorable for utilization of this species. See Appendix V-2, page 68 for further details.

[j] Perch (Perca flavescens)

This is the most abundant gamefish in the Palisades area. The principal impact would be on juveniles in the near-shore area that

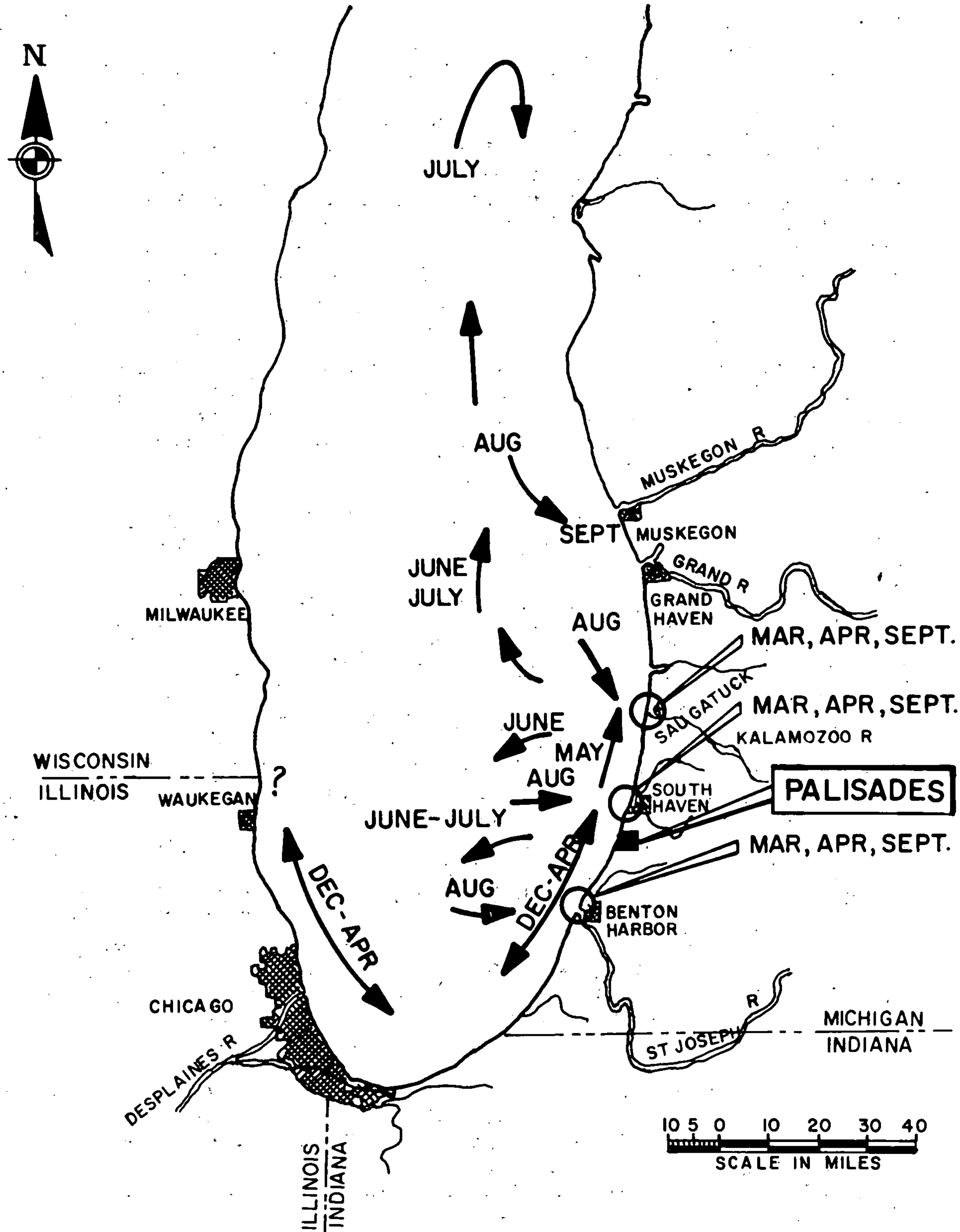

Fig. V- 12
Annual Movements of Coho Salmon in Southern Lake Michigan

could be displaced by the warm plume or chlorine in summer (Fig. V-13). A small number of adults attracted to the discharge in winter may be unable to reproduce successfully. Detailed analysis is presented on p. A-68.

[k] American Smelt (Osmerus mordax)

Smelt occupy the area of the lake in which the Plant intake is located and some may be drawn into the cooling water (Fig. V-14). Water velocities are low at the unscreened margins of the intake crib, but are too high at the intake pipe (9 fps) for smelt to swim against. Shoreline spawning may occur (although most spawning is in tributaries) and eggs and fry may be drawn into the thermal plume and damaged by thermal shock or chlorine toxicity. Some smelt may attempt to spawn in the discharge (as an artificial tributary). Insufficient data are available to judge whether the impacts on smelt will be significant. For further details see p. A-70.

[l] Spottail Shiner (Notropis hudsonius) and Trout-perch (Percopsis omiscomaycus)

The distribution of these two species places them in proximity to the inlet structure during fall and winter and to the thermal discharge in spring and summer. Impact will depend upon behavior of the fish, which is poorly understood (Fig. V-15).

ii. Toxicity of Chlorine to Fish

Chlorine is toxic to fish. It is instructive to compare the proposed 0.5 ppm chlorine residual for Palisades with toxicity information in the biological literature. (see Fig. V-2). Merkens[72] found that at a pH of 7.0, 0.08 ppm of residual chlorine killed half of his test fish in 7 days. Zillich[73] found chlorinate sewage effluent to be toxic to fathead minnows at residual chlorin concentrations of 0.04 to 0.05 ppm. Basch[74] found that 50% of a population of rainbow trout could tolerate 0.23 ppm for only 96 hr. Arthur and Eaton[30] showed that the highest concentration that produced no effect on the life cycle of the fathead minnow was 0.016 ppm. Sprague and Drury[31] showed an avoidance response by rainbow trout to free chlorine levels of 0.001 ppm.

The Palisades discharge can be expected to induce toxic concentrations of chlorine or chloramines over sizeable areas. With strong alongshore currents, about 2 miles of shoreline will be traversed before dilution brings an initial 0.5 ppm chlorine to nontoxic levels. Since this zone is heavily used by juvenile fish in summer, the

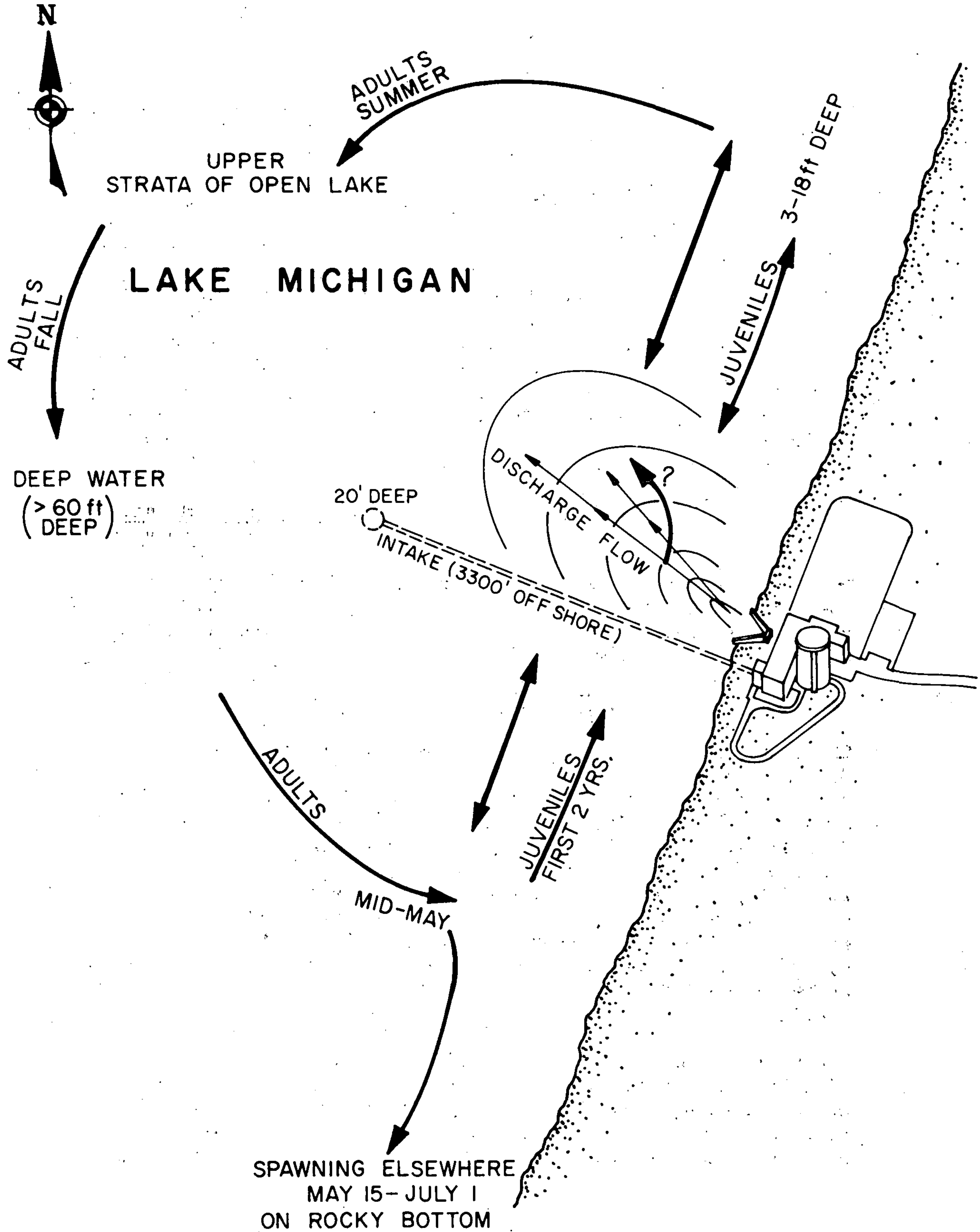

Fig. V-13
SCHEMATIC DIAGRAM OF LIFE CYCLE OF PERCH IN RELATION TO THE PALISADES PLANT

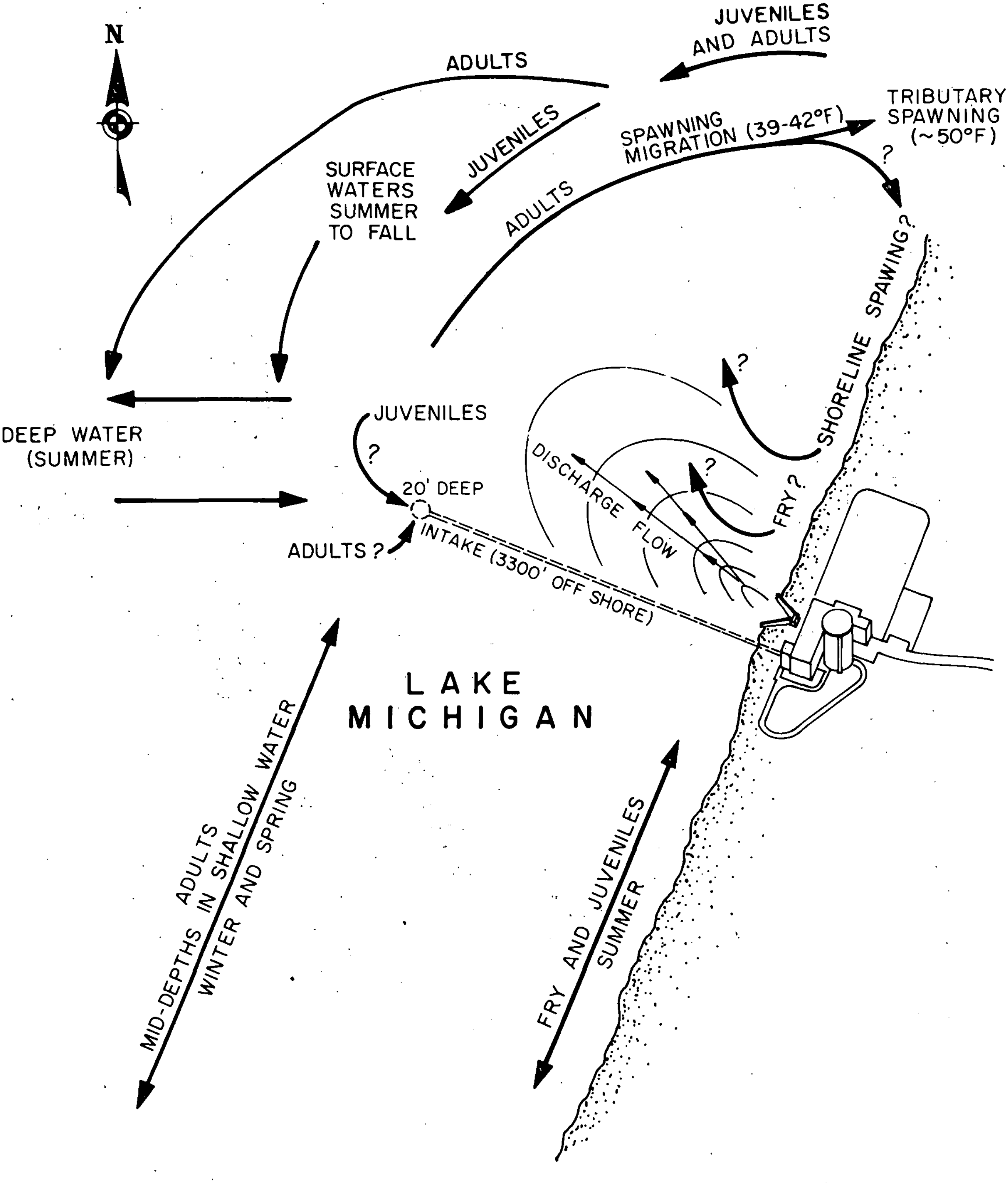

Fig. V - 14
SCHEMATIC DIAGRAM OF THE LIFE CYCLE OF SMELT IN RELATION TO THE PALISADES PLANT

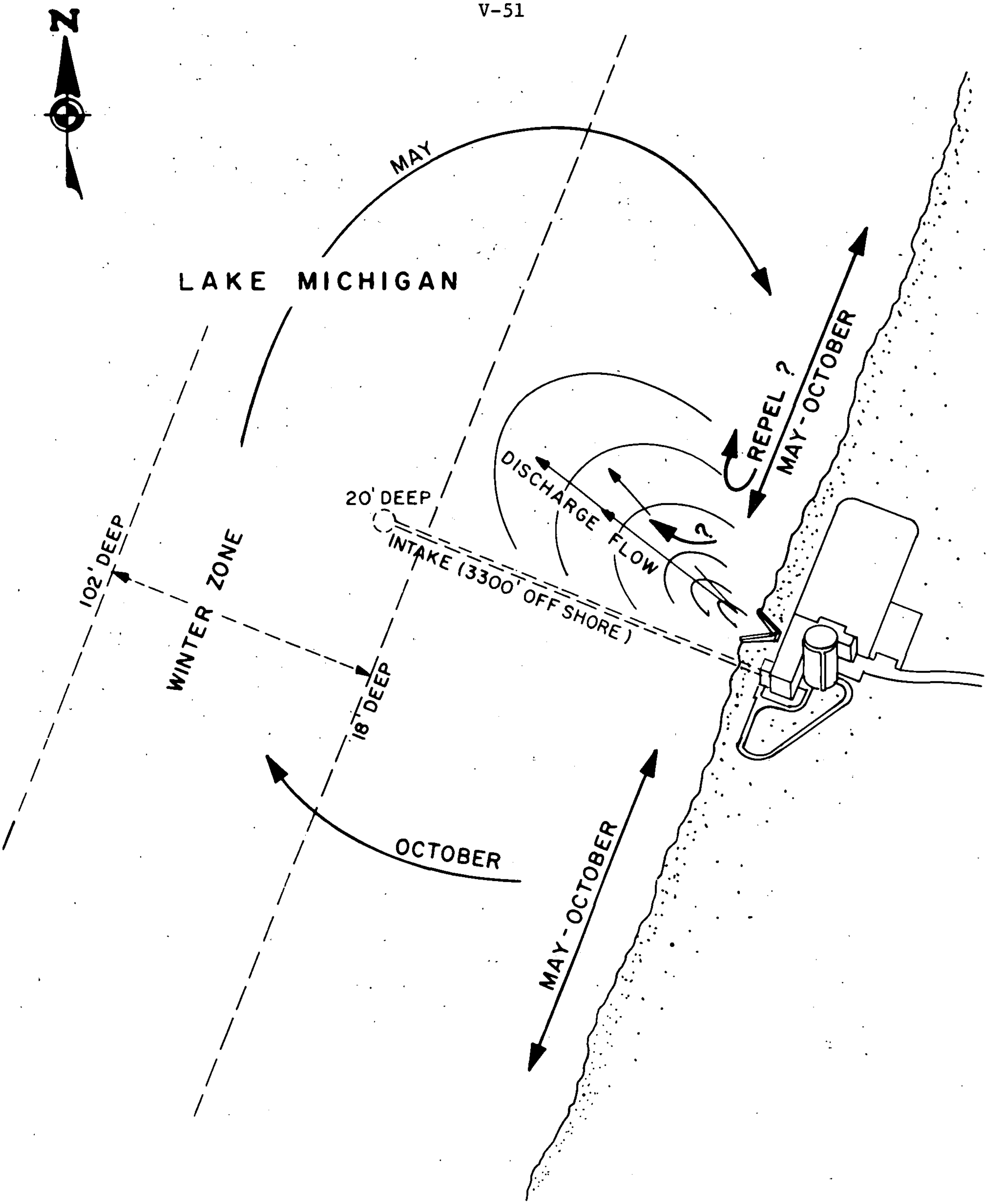

Fig. V- 15

SCHEMATIC DIAGRAM THE SEASONAL DISTRIBUTION OF THE SPOTTAIL SHINER AND TROUTPERCH IN RELATION TO THE PALISADES PLANT.

impact could be significant, either through mortality or (more likely) exclusion of the area as suitable habitat. Among juveniles of the major species discussed in the Section V.C.1.c(2)(d) above, the most obvious possibilities of danger from chlorine in the plume are fatal to juvenile cisco during shoreline movements from mid-spring through late summer, displacement of juvenile perch in summer and damage to fry and eggs of the American smelt during possible shoreline spawning.

It is concluded that limitation of the residual chlorine concentration of 0.5 ppm at the point of discharge into Lake Michigan and restriction of the length of the chlorination treatment to one hour per month should reduce, but not eliminate, the adverse effect on aquatic biota near the Palisades Plant site. If observations during chlorination reveal mortalities or evidence of stress in local populations, the applicant shall be required to reduce the duration of treatment or concentration of chlorine residual to minimize effects on lake biota. It is understood that chlorine discharge will diminish greatly after completion of the closed cycle cooling system.

(3) Applicant's Initial Ecological Monitoring Program

An ecological monitoring program had been established to identify effects of the cooling water discharge on Lake Michigan.[66] The regulatory staff has concluded that the original program is not adequate to identify many of the more likely effects of the discharge on lake biota. Our reasons follow a brief description of the existing program. [Radiological monitoring is discussed in Section D of this chapter.]

Because of the inadequacies of the original ecological monitoring program, it is being modified according to the requirements of the Technical Specifications issued for the proposed limited operation of the Palisades Plant at 60% of rated power in connection with the staff's testimony presented in the Hearings held on January 25-26, 1972.[75] The State of Michigan, Department of Natural Resources also had recommended to the applicant modifications of the original environmental programs.[76] The modified ecological monitoring program is discussed in the next subsection [Section V.C.1.c(4)].

(a) Description of the Original Survey Plan

The study plan was developed for the applicant by biologists on the staff of the University of Michigan.[78] Collection and analysis of biological data have been contracted to T. W. Beak Consultants, Ltd., in cooperation with the Michigan Department of Natural Resources. Sampling began in 1968 and will continue at least until the end of 1973.

Parallel studies are under way at the applicant's existing fossil-fueled stations on Lake Michigan which are important for making predictions for the Palisades site, particularly of long-range effects. The principal investigation has been at the 650 MWe J. H. Campbell Plant, located about 40 miles north of Palisades. Characteristics of the discharge and the lake ecosystem are sufficiently similar that useful physical data can be transferred to the Palisades site.

The ecological studies have considered bottom organisms (with the exception of the psammo-littoral community), plankton, attached algae, fish, and water quality characteristics (dissolved oxygen, temperature). The bottom organisms were considered to be the most delicate indicators of ecological change since they are generally sessile and cannot escape stressing environmental conditions. Fish were not emphasized, due to the belief that they could avoid detrimental conditions and that their long life span indicated too slow a population response to environmental changes. It is apparent that fish reproduction and survival of juvenile fish were not considered.

A basic fan-shaped sampling grid was established that is similar to the grid recommended by the Environmental Protection Agency.[79] Sampling stations were established at 1/4-, 1/2-, 1-, 2-, and 5-mile distances from the discharge point on nine radial lines (Fig. V-4). Two reference stations were located at the cities of South Haven and Benton Harbor, about 7 miles north and 16 miles south of the site, respectively. Samples were scheduled for collection in early May, late June, August, and October. There were 21 stations originally scheduled for bottom organisms, 10 for plankton, and 3 for attached algae. There has been some modification of the basic plan as experience has been gained.

Bottom samples are being collected by a dredge that cuts out approximately 0.5 square feet of bottom to a depth of 2 to 6 inches. The organisms are screened, identified, and counted. Analyses of samples taken prior to Plant operation will be compared to samples taken after startup. Distributions of pollution-tolerant and pollution-intolerant organisms will be compared, as will the species diversity of the entire community.

Plankton samples are obtained by passing 40 liters of water collected in a limnological sampler through a plankton net. Depths of 5, 10, and 15 feet are sampled. Preserved samples are centrifuged and the volume of concentrated cells is determined. It is presumed that volumetric measurements before and after Plant start-up will indicate if operation of the Palisades Plant stimulates the plankton.

Attached algae (periphyton) are collected on plexiglas plates suspended in the water at a depth of 15 feet. Scrapings of plates left for 4 weeks are analyzed for chlorophyll content.

Fish are collected by two principal methods, gill netting and beach seining. Personnel of the Michigan Department of Natural Resources have been conducting all fish collections. Gill nets of various mesh sizes are set for two 24-hour periods 4 times a year at depths of 20, 40, and 55 feet. The beach seine has been drawn along the shoreline immediately north of the Plant site. Additional data have been obtained for offshore fishes from trawl collections by the U. S. Fish and Wildlife Service. All captured fish are identified, counted, measured, and many are sexed, weighed, and growth data obtained from scales.

(b) Adequacy

The heavy emphasis on thorough monitoring of bottom invertebrates seems to have been a poor choice. Since the plume will generally stratify in the surface layers soon after leaving the discharge (Section III D), these organisms are among the least likely to be affected by the Palisades thermal plune and its entrained chemicals with the possible exception being the psammo-littoral community which has been ignored in the applicant's monitoring program. Bottom organisms are normally scarce in the nearshore waters where a surface plume would touch the bottom or where a plume would be forced upon the beach by strong onshore winds and alongshore currents. The psammon, however which live in the capillary spaces near the surface of the wet beach zone will be impacted first by the surface plume when there are alongshore currents and onshore winds, two conditions which will be the most common (54% of the time). This would appear to make the psammon an ideal community to monitor for detecting biological effects of Plant operation. These nearshore zones are also important habitats for young fishes including alewife, perch, whitefish, cisco, smelt, and others as described in Appendix V-2. In addition, the wave-washed sands are potential spawning sites for several fish species. And, not incidentally, the fish are the species that are used directly by man. A stronger emphasis toward monitoring effects on the psammo-littoral community and the reproductive and rearing phases of fish would seem to address the pertinent question more directly of the measurement of magnitude of impact of thermal discharges on biota.

The timing of sample collections seems to be geared to an annual calendar rather than to events likely to be important to the impact of the discharge on Lake Michigan biota. For example, several fish may spawn in November and December in areas affected by the plumes; young fish may pass through the critical phases of hatching and early rearing in March and April. At neither time are studies being made. The critical winter period for possible egg incubation passes without any measurements of the temperature distributions that may identify a "sinking plume." Plankton sampling at four times annually cannot possibly identify natural seasonal patterns, let alone any changes in them due to operation of the Palisades Plant.

The sampling grid for bottom organisms does not appear to recognize that a thermal plume will not (except in winter) touch bottom at the depths found at most of the sampling sites. These samples will provide interesting examples of lack of effect, but will not cover the near-shore areas where effects on the psammo-littoral community might be expected.

The plankton studies have little prospect of contributing to important knowledge of the magnitude of the impact of the Plant effluent due principally to an analysis that is too simplistic. Relative volumes of organisms will tell little about the changes in species composition that are important indicators of eutrophication. No distinction is made between plant (phytoplankton) and animal (zooplankton) components, nor of silt or sand that might enter a sample taken close to the bottom. Large clumps of Cladophora, that are displaced attached algae, are not distinguished from the true plankton.

Attached algae other than floating masses of detached Cladophora are of little importance in the Palisades region where bottom materials are mostly loose sand. Monitoring of growths on plexiglas plates does not appear to be addressing a relevant question of the effect of the Plant effluents on aquatic biota. On the other hand, careful examination of natural bottom materials for growing Cladophora would provide answers to these effects.

Perhaps the greatest deficiency in the applicant's original nonradiological monitoring program lies in the adequacy of fish monitoring. Contrary to the basic assumption of the monitoring program, the fish community may be quite sensitive to thermal additions,, particularly during reproduction and rearing of young. No attempt has been made to design a monitoring program that could assess these impacts. The applicant did not indicate that it will record the number of fish (if any) that are killed by impingement on the traveling screens.

No monitoring procedures appear to be directed to identifying ecological impacts of chlorine separately from heat except for routine analysis for residual chlorine in the discharge canal during treatment. Yet to correct for environmental damage, one must know the causative factor. Portions of the biota (e.g. benthic organisms) will, of necessity, reflect the most adverse recent past condition (e.g. a single, highly toxic slug of chlorine) which may not be identifiable after it has occurred; others can be examined separately during periods with and without chlorination.

The temperature monitoring program apparently did not originally include continuous measurement of intake and discharge temperatures. Such measurements appear to be useful for a monitoring program for thermal effects and the applicant has recently installed the necessary equipment for continuous measurement of temperature differences of the intake and discharge water of the cooling system.

(4) Modified Ecological Monitoring Program

The original nonradiological ecological and monitoring program as discussed in the preceding paragraphs is considered to be inadequate to assess accurately the effects of operation of the Palisades Plant. In particular, it will not allow discovery of trends and effects on primarily aquatic biota (i.e., changes in reproduction, migration patterns, growth rates, species diversity, etc.) resulting from operation with the present once-through cooling system. The modified program should improve the capability of the applicant to assess any environmental impact from operation of the Palisades Plant and to adopt procedures that will permit early discovery of adverse impacts.

The requirements of the modified program are as follows:

(1) Sample the discharge water and the plume and inspect for evidence of detrimental effects on aquatic life, such as fish kills or fish in distress, during and after the

chlorination treatment, i.e., the one-hour per month discharge of effluent with 0.5 ppm residual chlorine.

(2) Make continuous temperature measurements of the intake and discharge water and thermal plume. Determine the actual size and shape of different excess isotherms, including the 3 F° excess isotherm. Develop a thermal plume model, using the information obtained from the temperature measurements of the different isotherms so as to be able to predict the behavior of the plumes.

(3) Implement a program to identify and record the numbers, types and sizes of collected fish that may be killed at the trash racks and traveling screens. During intense fish dieoffs that may overload the capacity of the census, estimate the numbers and kinds of fish using a reliable technique.

(4) Expand the ecological monitoring program to take into consideration the recommendations of sampling and analysis of different biota by the State of Michigan Department of Natural Resources,[76,77] and include the following:

Benthos

Benthic sampling stations shall be added in control and discharge areas at depths between the 20-foot depth contour presently stated and a point on the water-saturated beach. A sufficient number of sampling points shall be established to characterize the psammo-littoral community and to provide evidence of changes due to Plant operation.

Plankton

A separate accounting shall be made of zooplankton species and numbers at those stations for which detailed analysis of phytoplankton is planned. Since shoreline waters are most closely scrutinized by the public, a series of sampling stations shall be added in beach waters downwind of the discharge when strong alongshore currents prevail.

Periphyton

Since the periphyton community does not naturally occur on the sandy substrate in the vicinity of Palisades, the sampling program as outlined by the applicant seems unnecessary. The sampling area for benthic organisms shall also be surveyed for occurrence of filamentous algae in order to detect any increases in bottom area colonized or shoreline accumulations due to Plant operation.

Fish

The sampling program shall include additional studies to:

1) identify spawning fish and egg incubation areas near the Palisades Plant or to reasonably determine that such spawning does not, in fact, occur;

2) determine the numbers of juvenile fishes using the nearshore zone area for a nursery area and the number of these found in the thermal plume (with studies of survival in the plume if young fish are found there);

3) identify fish mortalities and fish in apparent stress during cyclic or abnormal operation of the Plant, including chlorination periods or shutdown;

4) fish collected on the traveling screens shall be inventoried on a routine basis, with fish counted, sized, and identified.

The modified monitoring program will be useful to assure that the applicant has met the State and Federal discharge standards for water certification, radiological, or other standards. Furthermore, it will be necessary in order to assess the potential damage to fish and other aquatic biota from the effluents from the Palisades Plant. This will assure that prompt action will be taken, during inadvertent releases or abnormal conditions, so that the aquatic biota of Lake Michigan and the surrounding area will be preserved and the health and safety of the public will be maintained. Details of the ecological monitoring program and effluent releases are also spelled out in the Technical Specifications. The applicant has already initiated the above monitoring program during operation at 60% of rated power and shall be required to continue it throughout the full power license with the once-through cooling and for at least two years after the closed-cycle system is installed.

The results of a good ecological monitoring program will be of general assistance to the utility industry in the design of future power plants. The information and data collected by the applicant or its consultants should also be analyzed and evaluated by an independent organization such as a university. In this manner an independent assessment of the environmental impact of the Plant can be made and used in future power plant design and operation to minimize any adverse impact. In this assessment, measurements of biological impact should be closely interlocked with the measurements of physical and chemical parameters.

d. Semiaquatic Biota

The increasing discharge of warmed effluents (both industrial and domestic) into northern streams and lakes has changed the duration and extent of normal ice cover in these water bodies and has changed normal over-wintering patterns of some species of waterfowl. Thus Hunt[80] details the increasing use of the Detroit River as a wintering area for Black Duck, Canvasback, Lesser Scaup, and Redhead since 1930. Neill (W. Neill, University of Wisconsin, Madison) has observed concentrations of ducks during winter in an area of Lake Monona kept ice-free by a power plant discharge. There have been large concentrations of wintering waterfowl downstream from the Commission's Hanford reactor complex on the Columbia River, due partly, perhaps, to somewhat warmer water there.[14,27] Several species of gulls may also be attracted to open water caused by thermal discharges.

The detriment of this process is that waterfowl may become crowded into areas near industrial complexes with a shrinking supply of winter food.[80] The proximity of sources of pollutants, food storage, and low air temperatures often interact to produce unusually high waterfowl mortalities.

The likelihood of this process occurring at the Palisades Plant is difficult to predict. As noted in Section V.A.1, shore ice is not expected to be much different than at present, although an open channel is anticipated from the discharge point to either the normal open lake or to the consolidated ice pack when that is extensive. The warm water of this channel could be an attractant. The area of such an open channel could be reduced markedly by use of a submerged diffuser system for warm water release.

e. Indirect Effects

(1) Synergism of Temperature and Other Pollutants

It is well known that temperature, as the master factor affecting rates of all metabolic functions, can influence the speed with which toxic substances exert their effects and, in some instances, can influence the threshold concentrations for toxicity.[84] Such influences could be expected in the thermal plume from the Palisades Plant.

Lake Michigan water quality at the Palisades site is currently good,[42] and there are strict controls over the concentrations of toxic substances that it may contain. Increases in concentrations of toxic materials for which temperature changes would be a significant factor in toxicity to aquatic life would be regulated independently. The applicant is required to meet local, State, and Federal Regulations on discharges including those under Section 13 of the Refuse Act of 1899 and Section 21(b) of the Federal Water Quality Improvement Act of 1970. The applicant has applied for the necessary applications under the Federal Regulations and these applications are being reviewed. The applicant has received from the State of Michigan Water Resources Commission its Order of Determination No. 931, on October 27, 1966, which has since been amended on November 19, 1971 for the purpose of establishing the size of the mixing zone (a circle with a radius of 3,630 feet). This Order also conditions the type, amount, and concentrations of discharges to assure the health and safety of the public and aquatic biota are protected.

The effect of increased temperature on the toxicity of poisons to fish is generally to reduce their time of survival in relatively high lethal concentrations, but median threshold concentrations may not be markedly changed or may even be increased; the results of laboratory tests suggest that an increase in temperature of 14.4 F° (8 C°) would reduce the 48-hour median lethal concentration of zinc for rainbow trout by a factor of 1.8 (i.e. increase toxicity) but increase it (i.e. reduce toxicity) by about 1.2 for phenol, by 2.0 for undissociated ammonia, and by 2.5 for cyanides.[82] An assessment of threshold effect has not been done on a sufficient number of compounds to allow a clear generality, or prediction of effect for the myriad of materials that may be discharged into Lake Michigan water.

(2) Cold Kills of Fish

A potential adverse effect of a thermal discharge is metabolic acclimation of fishes to such abnormally warm temperatures that they cannot tolerate sudden cooling should the heat source cease. Naturally occurring cold kills have been reported for the Great Lakes when changes in summertime stratification produced sharp temperature decreases on the order of 30 F°. The temperature drops required to kill some species have been published, and generally are about 25 to 30 F°. See Table V-3 for summertime acclimation temperatures. Recent experiments at Oak Ridge National Laboratory have shown that a drop of greater than about 5 C° (9 F°) is necessary to stress juvenile channel catfish sufficiently to induce an increase in vulnerability to predation. The likelihood of a significant cold kill at the Palisades facility is small, principally because there is but a small area in the discharge where fish could take up residence in water sufficiently warm to allow a cold kill. A cold kill at the applicant's Campbell Plant in 1968 was believed to affect mostly fish that had been residing in the warm water of the long discharge canal.[83] There is further detailed discussion of this topic under individual species in Appendix V-2.

(3) Dissolved Oxygen Content

There should not be a significant change in the dissolved oxygen content of Lake Michigan water as it passes through the Palisades Plant and through the discharge plume. This conclusion is based on an extensive review of the literature relevant to this question[14] and on operating experiences of power plants located on Lake Michigan.[15]

Since warm water can hold less oxygen in solution than can cooler, water, an elevation of water temperatures by 25 or 28 F° in passing through the condensers will theoretically result in some loss of oxygen that may subsequently influence aquatic organisms. For example, the air equilibrium oxygen concentration in water at 82.4°F is 7.9 ppm whereas at 111.2°F the saturation concentration is 6.1 ppm. Another factor theoretically tending to lower dissolved oxygen concentrations in the water passing through a condenser is the partial vacuum existing at the discharge end of the condenser.[14]

These theoretical considerations have been examined in a number of studies at operating power stations throughout the world. Alabaster and Downing,[84] after examining literature and conducting their own studies in Britain, acknowledge that the dissolved-oxygen content of water used for direct cooling may change slightly in its passage through electricity generating stations. This appeared to be partly due to the turbulent flow in the effluent outfall causing water unsaturated with dissolved oxygen to pick up this gas, while supersaturated water lost it. If the initial concentration is near the air-saturation value, the increase in temperature in the condensers can cause supersaturation. Thus cooling-water discharges tend to increase slightly the dissolved-oxygen content of river water where concentrations are low and to reduce it where they are above saturation.

Table V-3. Lower Incipient Lethal Temperatures of Freshwater Fish Found Near the Palisades Plant. The Temperature Responses Are Used to Assess Impacts of Sudden Drops in Water Temperatures

Species	Acclimation Temperature		Low Incipient Lethal Temp.		Δt		Reference
	°C	°F	°C	°F	°C	°F	
<u>Catostomus commersonni</u>	20	68	2.5	37	17.5	31	Hart, 1947(129)
(white sucker) adult	25	77	6.0	43	19	34	
<u>Coregonus artidii</u> (cisco)	2	36	<0.3	<32.5	1.7	3.5	Edsall and Colby,
Juvenile	5	41	<0.5	<33	4.5	8	1970 (130)
	10	50	3.0	37	17	13	
	20	68	4.7	40	15.3	28	
	25	77	9.7	49	15.3	28	
<u>Dorosoma cepedianum</u>	25	77	10.8	51	14.2	26	Hart, 1952 (131)
(gizzard shad) juvenile	30	86	14.5	58	15.5	28	
	35	95	20.0	68	15	27	
<u>Ictalurus nebulosus</u>	20	68	0.5	33	19.5	35	Hart, 1952 (131)
(brown bullhead)	25	77	4.0	39	21	38	
	30	86	6.8	44	23.2	42	
<u>Ictalurus punctatus</u>	15	59	0	32	15	27	Hart, 1952(131)
(channel catfish) adult	20	68	0	32	20	36	
	25	77	0	32	25	45	
<u>Lepomic machrochirus</u>	15	59	2.5	37	12.5	22	Hart,1952 (131)
	20	68	5.0	41	15	27	
	25	77	7.5	46	17.5	31	
	30	86	11.0	52	19	34	

Table V-3. Lower Incipient Lethal Temperatures of Freshwater Fish Found Near the Palisades Plant. The Temperature Responses Are Used to Assess Impacts of Sudden Drops in Water Temperatures (continued)

Species	Acclimation Temperature		Low Incipient Lethal Temp.		Δt		Reference
	°C	°F	°C	°F	°C	°F	
Micropterus salmoides (largemouth bass)	20	68	5.5	42	14.5	26	Hart, 1952(131)
	30	86	11.8	53	18.2	33	
Notemigonus crysoleucas (golden shiner) adult	15	59	1.5	35	13.5	24	Hart, 1952(131)
	20	68	4.0	39	16	29	
	25	77	7.0	45	18	32	
	30	86	11.2	52	18.8	34	
Notropis atherinoides (emerald shiner) juvenile	15	59	1.6	35	13.4	24	Hart, 1947(129)
	20	68	5.2	41	14.8	27	
	25	77	8.0	46	17	31	
Notropis cornutis (common shiner) adult	20	68	3.7	39	16.3	29	Hart, 1947(129)
	25	77	7.8	46	17.2	31	
Oncorhynchus Kisutch (coho salmon) juvenile	5	41	0.2	32	4.8	9	Brett, 1952(132)
	10	50	1.7	35	8.3	15	
	15	59	3.5	38	11.5	21	
	20	77	4.5	40	15.5	37	
	23	86	6.4	44	16.6	42	
Oncorhynchus tshawytscha (chinook salmon) juvenile	10	50	0.8	33	9.2	17	Brett, 1952(132)
	15	59	2.5	37	12.5	22	
	20	68	4.5	40	15.5	28	
	23	73	7.4	45	15.6	28	
Perca Flauescens (yellow perch) adult	25	77	3.7	39	21.3	38	Hart, 1947(129)
Pimephales notatus (bluntnose minnow) adult	15	59	1.0	34	14	25	Hart, 1947(129)
	20	68	4.2	40	15.8	28	
	25	77	7.5	46	17.5	31	

Table V-3. Lower Incipient Lethal Temperatures of Freshwater Fish Found Near the Palisades Plant. The Temperature Responses Are Used to Assess Impacts of Sudden Drops in Water Temperatures (Continued)

Species	Acclimation Temperature		Low Incipient Lethal Temp.		Δt		Reference
	°C	°F	°C	°F	°C	°F	
Pimephales promelas	20	68	1.5	35	18.5	33	Hart, 1947(129)
(fathead minnow) adult	30	86	10.5	51	19.5	35	
Rhinichthys atratulus	20	68	2.2	36	17.8	32	Hart, 1947(129)
(blacknose dace)	25	77	5.0	41	20	36	

Samples taken by Alabaster and Downing[84] to determine dissolved-oxygen concentration showed that most unheated water was not saturated and that there was either a slight rise in concentration in the heated water (due to pumping and mixing at the discharge) or littl difference from that in the normal river water. These authors made the further observation that the changes were generally small compared with those which occur in most natural waters through plant photosynthesis and respiration, through aeration at dams, and through the oxidation of organic effluents.

Adams[85] has reported similar analyses at California power stations. Measurements of dissolved oxygen at intake and outfall points showed that dissolved-oxygen concentrations were not decreased in passing through the cooling water system. Rather, the water merely became supersaturated with dissolved-oxygen. As temperatures of the effluent dropped in the mixing zone, saturation values dropped correspondingly, with little loss of dissolved-oxygen.

Studies conducted at Lake Michigan thermal effluents further confirm the conclusion that dissolved-oxygen changes are insignificant in lake waters used for cooling.[15]

Once the cooling water has entered the lake, rates of oxygen demand by organic materials (both living and decomposing) will be increased due to increased temperatures. In waters that are heavily loaded with decomposing organic matter, this additional demand can exceed the rate of reoxygenation through the water surface (from the air) and dissolved oxygen levels can fall below those normally expected.[86] While this has been demonstrated elsewhere, it is unlikely to occur at the Palisades site. Reoxygenation equations given for previous studies indicate that organic loading of Lake Michigan water at Palisades is not high enough to produce decreases in dissolved oxygen that would be significant for biota.[87]

f. <u>Estimates of Damage</u>

A gross estimate of damage to aquatic biota can be made assuming that all organisms entrained in the cooling water are killed by a combination of environmental effects, including impingement on screens, and that these are related to the total fish catch of Lake Michigan. The cooling system will use 405,000 gpm of lake water of a total volume of about 1.28×10^{15} gallons, or a use of 0.017% of Lake Michigan water each year. Assuming a fish density of 25 pounds per acre in 1.43×10^{7} acres, one can arrive at an annual environmental cost of about 60,000 pounds of fish as an estimated damage to the aquatic life in Lake Michigan from operation of the Palisades Plant.

2. Differences Due to Closed-Cycle Cooling Tower System

While cooling towers seem to offer overwhelming advantages for alleviation of the effects which are believed to be associated with discharge of heat to water bodies, their operation can have a distinct impact on their surroundings. Wet towers, both the forced draft (mechanical) type proposed for use at the Palisades Plant, or those that depend on natural draft, are likely to cause more environmental problems than dry towers, but in general, they are much more efficient and less costly. Some of the characteristics of wet-tower operation that may have impacts on the environment are summarized in the following section.

a. Sources of Potential Biological Damage

There are three principal sources of potential biological damage after installation of the mechanical draft cooling towers and modified radioactive waste system described in Section III.D and V.E in addition to others common to both cooling systems. These three sources are:

(1) Moisture from evaporation and airborne drift that is deposited on surrounding land affecting terrestrial plants through wetting and icing.

(2) Chemicals from liquid blowdown of recirculating cooling water to the lake, which may be toxic or stimulatory to aquatic life. There is a wide variety of alternative chemicals used as biocides and corrosion inhibitors, as described in the Appendix Section V-1.

(3) Chemicals from airborne drift that are deposited on surrounding land, with potential problems of toxicity to terrestrial plants and animals.

Other sources will be present in the closed-cycle system as in the once-through system, although each will be reduced substantially. These are:

(1) Temperature increase from elevated temperature of the blowdown flow (the cooling towers will produce a temperature evaluation of < 5°F in a flow to the lake of 60,000 gpm compared with an elevation of about 25 F° in 405,000 gpm during once-through cooling).

(2) Mechanical and pressure changes that damage small organisms pumped with the 60,000 gpm blowdown dilution flow.

(3) Impingement on intake screens of fish that enter the intake with the 60,000 gpm dilution flow and makeup water.

(4) Chemicals such as from chlorine (reduced from 0.5 ppm to 0.022 ppm (closed-cycle) at the discharge, both being intermittent) and other process chemicals that may be toxic to aquatic life.

(5) Induced circulation of the nearshore water at the point of discharge.

(6) Radiation from very low concentrations of certain radionuclides not effectively removed by the modified radioactive waste system.

Impacts from these sources are discussed in more detail below under the segments of the biota that will be affected, and in Appendix V-1.

Chemicals used in closed cycle cooling systems deserve particular emphasis as potential sources of environmental degradation (Appendix V-1). Their potential for degrading water quality and the land surrounding the cooling towers has been assessed in the following discussion. Careful evaluation of toxicity, food chain accumulation, stimulation of nuisance algae, and the technology of removal of chemicals from blowdown and drift appear to be very important for proper consideration of impacts of closed-cycle cooling. Nearly all the chemical impacts of blowdown to the lake could be avoided by installation of water treatment facilities as discussed in Appendix III-1. Cooling tower suppliers are actively seeking to reduce airborne drift.

The proposed cooling towers will also use chlorine. The concentration in the blowdown (1,320 gpm) discharge will be 1 ppm for 1 hour each day. The chlorine residual will be 0.022 ppm after dilution of the blowdown by 60,000 gpm and the area affected by chronic low levels will be smaller than for once-through cooling. However, the period of chlorine discharge will be 30 times longer than for once-through cooling.

There should not be additional dissolved-oxygen losses to Lake Michigan water by replacement of the once-through system with a closed-circuit cooling system using cooling towers. The tower blowdown will be well aerated due to extensive exposure of water droplets to air flow in the towers. Dilution water should not lose oxygen during pumping. Oxygen demand by organic matter in the plume will be less than in the once-through system due to lower temperatures and smaller areas of influence.

b. Terrestrial

There are two potential sources of impact on the terrestrial environment resulting from operation of the proposed mechanical-draft cooling towers at the Palisades Plant (see Section III.D.1.b. for a description of these cooling towers and their proposed location of the site). These sources are: 1) evaporative water losses, which will be 12,300 gpm (according to the applicant), and 2) airborne drift which will have the same chemical concentration as the blowdown water prior to dilution. Total water losses in draft are guaranteed not to exceed 820 gpm by the applicant and are estimated to be 20 gpm.[7]

Several dunes in the proposed area of the cooling towers are over 100 feet high while the cooling towers will be only 50 feet high. Many trees on the site reach 50 to 80 feet. By placing the towers in dune valleys (incompletely healed blowout wind channels), the effects of vapor plume and drift from the cooling towers may be attenuated locally instead of reaching the highways (I-196 and U.S. Highway 31).

Much of the time the plume will first impinge upon and spread over the upper dune slopes. The influence of moisture will probably be favorable for plant growth during the warmer half of the year because drought and high winds are widely recognized as limiting factors on the dry dune summit ecosystems.[89,91] However, during the colder half of the year, icing is expected to be a pronounced local ecological problem, breaking down the branches of larger trees and even of shrubs much more than normal winter storms would. Vegetation succession will tend to revert toward conditions of pioneer communities; shrubs and grasses may or may not retain sufficient strength to prevent expansion of blowout areas (during dry weather) in the locations where plume impact will be worst. Grading during construction around the cooling towers would decrease protection and increase wind channeling.

Cold weather is often associated with northwesterly winds in this area following passage of polar fronts, so the northwesterly facing dune slopes will be impacted most intensively by ice.[91] Balanced balloons over a Michigan dune not far from Palisades showed complex wind trajectories; these presumably also would be illustrated by the plume paths as gusty winds swept around and beyond the towers. Even southwesterly winds are often accompanied by day and night temperatures below freezing for days at a time so slopes facing south and west also would be affected by icing from the cooling tower plume. Instead of damage that could repair itself by plant growth after natural ice storms of a few hours duration, there would be a cumulative effect over the weeks and years for an area which would gradually enlarge.

A potentially more serious question than icing concerns deposition on the dune slopes of materials in the airborne drift from the towers. During wet weather, or in seasons when leaves are falling, zinc or other toxic elements in the drift (Table V-4) also would tend to accumulate with organic litter on the ground instead of on the green vegetation. Downwash during the winter season will increase the localized deposition of these materials.[7] Considering the concentrations and total losses of certain chemicals such as sulfate and zinc, there could be a severe impact on the plant and animal communities in this area surrounding the cooling towers. Displacement of ion nutrients by cation exchangers in humus would accelerate leaching of nutrients from the dune soils, which are already of poor fertility.[89] Cation exchange capacity approximates 8 milliequivalents per 100 grams of soil (lower on young or dry sites).[89] Accelerated nutrient losses of nitrate and phosphate is possible by displacement from extraordinary loads of sulfate in the places most often drenched by cooling tower plumes. Depending on the intensity and extent of these chemical impacts, decreased productivity of these dune communities could produce shifts in species succession and even some further loss of protective cover which presently keeps the winds from resuming sand blowing.

At the maximum drift rate, some 12 lb/day of zinc would be transferred to the area around the cooling towers. Although this transfer rate of the metallic ion is unquestionably excessive, a considerable amount of the element can be expected to accumulate in the surroundings after the towers have operated for long periods of time. The exact effect of such accumulation in dune growths is not certain. It is axiomatic with ecologists, however, that the steady accumulation of the transition metal ions in a vegetated area will cause increasing difficulty in maintaining healthy vegetation.

Only after there had been time for considerable cumulative deposition, or by instituting special tracer studies (e.g., with artifically applied radioactive tracers), would it be known which of the chemical elements were being leached out of the underlying sand faster than they were being deposited, and which were accumulating through reabsorption in plant and animal food chains at sufficiently rapid rates to cause toxic effects.

In summary, the impact of ice may be less serious, even in the long run, than effects of chemicals contained in the airborne drift from

Table V-4. Estimated Concentrations of Chemicals in Airborne Drift From the Proposed Mechanical-Draft Cooling Towers at the Palisades Plant, and Estimated Losses of the Chemicals on Assuming Water Loss in Drift to be (a) 820 gpm and (b) 20 gpm

Species	Concentration (ppm)	(a) Loss Pounds/Day	(b) Loss Pounds/Day
Na^{+}	106	1045	25
Ca^{2+}	336	3311	80
Mg^{2+}	112	1104	27
Cl^{-}	90	887	22
SO_4^{2-}	1,262	12,436	302
HCO_3^{-}	80	788	19
SiO_2	21	207	5
PO_4^{3-}	12	118	3
Zn^{2+}	1.2	12	0.3

the cooling towers, or in the salts left behind by evaporation of the drift. Uncertainties of meteorology and of geochemical cycles in the dune ecosystems make it impossible to evaluate the extent of damage on the terrestrial ecology from cooling towers placed in the manner proposed.

c. Aquatic Biota

(1) Plants

(a) Phytoplankton

Thermal and mechanical effects will be reduced compared to the once-through system in proportion to the decreases in temperatures and pumping requirements. The cooling tower system will have some advantages for these impacts. Damage to plankton in the blowdown water diluted by 60,000 gpm could be eliminated if a diffuser discharge were substituted in the lake for the dilution pumping.

Three chemicals will be released in quantities that may have an impact upon phytoplankton: phosphate, zinc, and sulfate (Table III-10, Section III.D.3.). Addition of the chemical phosphate by cooling towers at Palisades can be expected to increase algal growth in Lake Michigan. Phosphate is recognized as a principal mineral nutrient necessary for algal growth.[37] It is currently believed to be a controlling factor for nuisance algal growths in Lake Michigan,[93] which has resulted in water pollution control agencies restricting the addition of phosphate to the lake.

The proposed phosphate release from the cooling towers amounts to 12 ppm in a blowdown flow of 1,320 gpm although personal communications with cooling tower operators indicate that this may be somewhat less in actual practice. The excess concentration at the Plant discharge will be about 0.27 ppm after the blowdown is diluted. By comparison, the normal concentration of Lake Michigan phosphate has been reported to be 0.013 ppm with only slightly higher values in the extreme southern end.[94] The addition will thus raise the phosphate concentrations at the discharge by more than a factor of 20. The southern end of the lake has shown increasing trends toward eutrophication with far lower phosphate levels than will be induced by the Palisades cooling tower operations.[95] Addition of only 0.02 ppm additional phosphate to Lake Michigan water has been shown to stimulate additional algae growth.[93]

Phosphate additions to Lake Michigan will amount to about 69,500 lb/yr, which will be about 3.7 times the average yearly phosphate output by the Black River at South Haven, based upon data for 1964 and 1965.[42] The phosphate output of Palisades (without treatment of blowdown) will be equivalent to the phosphate contribution of about 640 square miles of the State of Michigan and a population of about 74,500 people, based upon the average phosphate output of all the State's tributaries. This figure excludes leaching of phosphate from airborne drift.

The immediate effects of phosphate enrichment near the Palisades site should be evidenced in the phytoplankton community. There may be some inhibition near the Plant due to chlorine when it is used, but once chlorine levels have fallen to below 0.1 ppm the plankton should respond quickly to the added nutrient, as it has responded to nutrient input from tributaties[42,96] (Figs. V-16 and V-17). The enrichment should favor certain species, perhaps the nuisance blue-green algae.[96]

Zinc released to Lake Michigan in cooling tower blowdown (1.2 ppm continuously at a rate of 1,320 gpm which will be diluted at the discharge to 0.036 ppm) will quickly attach to particulate matter, largely algae, and enter the food chain of the lake in high concentrations (Table V-5). Concentration factors for zinc in Columbia River algae averaged greater than 10,000 times water concentration.[97]

Zinc is a required micronutrient for algae, but high concentrations would be toxic. Toxicity could be reflected in death or sublethally by inhibition of photosynthesis. Insufficient evidence is available to estimate the effects of the proposed Palisades releases.

Sulfate ion is also necessary for plant growth, at a minimal level of 0.5 ppm.[98] Detrimental effects of much higher levels have not received study.

(b) Filamentous Algae and Vascular Aquatic Plants

As noted previously, the substrate at the Palisades site is unsuitable for attachment of filamentous algae or vascular aquatic plants. Thus total growths of *Cladophora* are not expected to develop even though there is an enhanced nutrient supply. There may be additional growth of drifting masses stimulated by locally increased phosphate levels, but this growth should be minor.

(2) Animals

(a) Benthic Invertebrates

The once-through cooling system will have negligible thermal impact on the benthic invertebrates; thus installation of cooling towers offers little advantage for this component of the Lake Michigan biota. There may be a slight reduction in numbers of entrained organisms which are killed, but entrainment of benthic organisms will be negligible since the intake structure is 6 feet above the lake bottom.

The concentration of chlorine released will be reduced from 0.5 to 0.022 ppm with the closed-cycle cooling system, thus the impact on benthic species and the psammon community in the wet beach zone should also be reduced. Dilution of the chlorine in Lake Michigan water should lower chlorine concentrations to below toxic levels

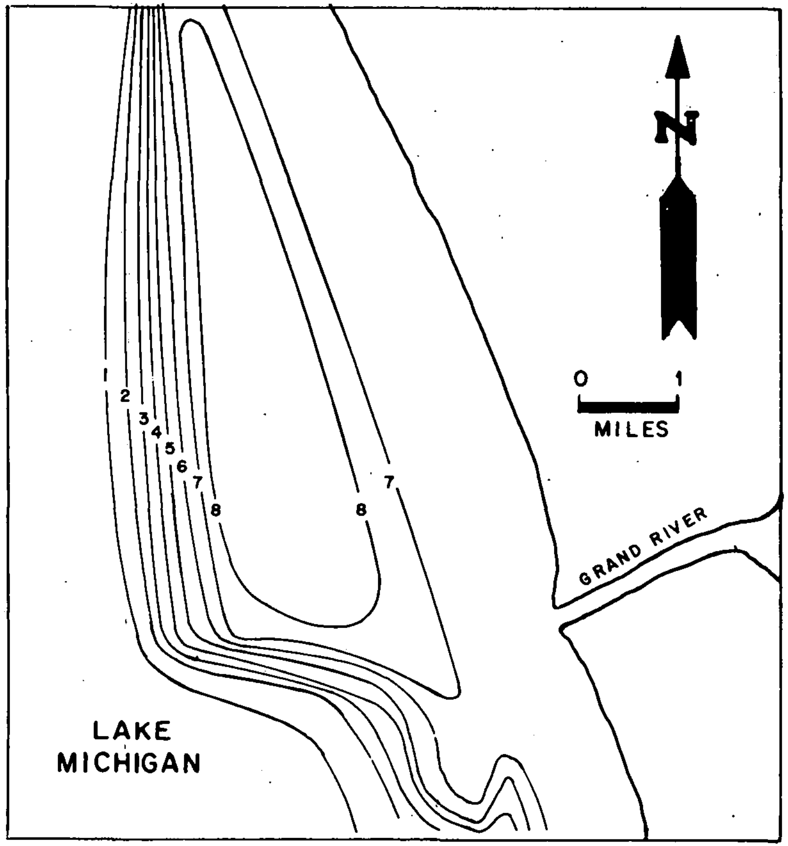

Fig. V- 16

GENERALIZED CONTOURS OF ADDITIVE TOTALS OF ALGAL CELLS PER FOUR 1-MI SAMPLES, GRAND HAVEN, MICH., VICINITY, 28 APRIL 1967 (Ref. 96). THIS REPRESENTS THE COMBINED EFFECTS OF ADDED TEMPERATURE AND NUTRIENTS FROM THE GRAND RIVER.

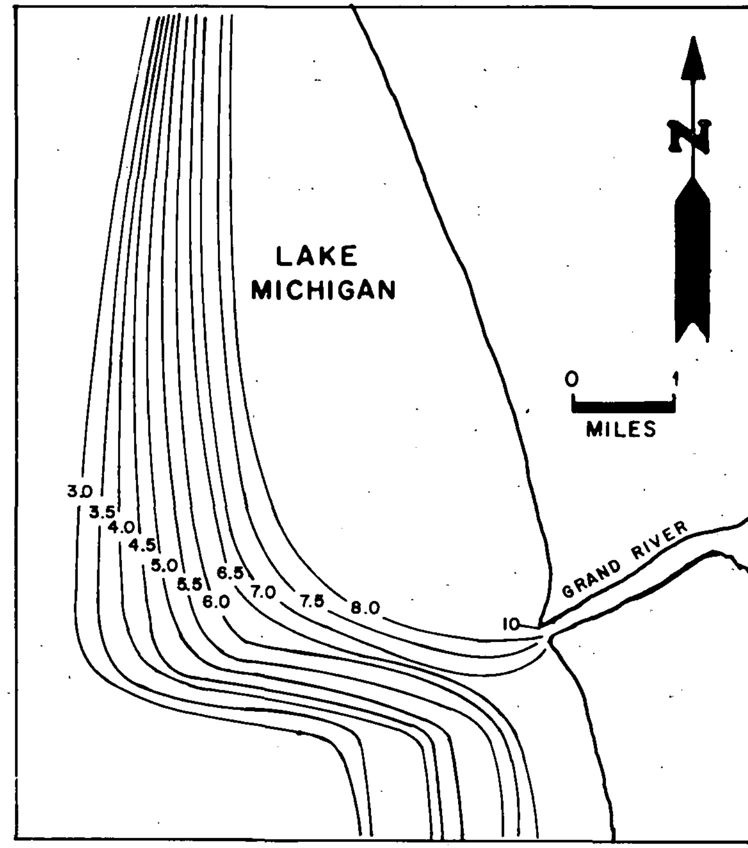

Fig. V - 17

GENERALIZED 0.5°C SURFACE TEMPERATURE CONTOURS, GRAND HAVEN, MICH., VICINITY, 28 APRIL 1967.

Table V-5. Estimated Concentrations of Zinc in Lake Michigan Biota in the Area of the Palisades Plant Based on Zinc Concentrations in Effluent Water and Concentration Factors Taken From the Literature

Compartment	Concentration (ppm)	
	Estimated Normal[a]	Predicted at Discharge (max)
Water	0.010	0.036[b]
Algae	335	871
Invertebrates	100	260
Fish	30	78

[a]From references 97 and 99.

[b]Zn concentration after dilution.

very rapidly, thus preventing any significant impact on benthic invertebrates. However, the reduced chlorine concentration will be offset by the increased frequency of discharge (1 hour per day) compared to once-through cooling (1 hour per month).

Benthic invertebrate species show a wide difference in their sensitivities to zinc; the highest concentration tolerated by Limnaea pereger, an aquatic snail, was 0.2 ppm, while water boatmen, stoneflies, and caddisflies could tolerate 500 ppm. Jones[101] found stoneflies, amyflies, and some Chironomidae (midges) living in a section of river containing 60 ppm of zinc from mine drainage. However, oligochaetes, leeches, crustaceans, and molluscs were absent from the polluted section of river. In light of these elevated levels, the release concentration for zinc from the Palisades Plant of 0.036 ppm (Table III-10) should not have an impact on benthic invertebrates.

Sulfate (SO_4^{2-}) will be released to Lake Michigan in relatively high concentrations from the Palisades Plant but the levels will not exceed the permissible surface water criterion for public water supplies which is 250 ppm.[16] With the closed-cycle cooling system discharge, concentrations will be approximately 48.9 ppm compared to the average lake concentration of 22 ppm (see Table III-10). These concentrations are large enough to promote the growth of the sulfate reducing bacterium, Desulfovibrio sp on the lake bottom. This organism is an anaerobic autotroph which reduces sulfate to hydrogen sulfide (H_2S); hydrogen sulfide is itself toxic to fish and invertebrates at concentrations less than 1 ppm.[102,104] The optimum growth temperature range for this bacterium is 24 to 43°C (75 to 109.4°F) but it can survive thermal and chemical stress.[104,105]

The organism is an obligate anaerobe and could develop beyond the well-mixed beach zone if organic matter accumulated and anaerobic conditions developed. The resulting H_2S could become an offensive odor to persons utilizing the beach and swimming in the area of the Palisades Plant. Also, toxic levels of H_2S could be produced in the water from reduction of the high concentrations of sulfate released to Lake Michigan from the Plant.

(b) Zooplankton

Replacement of the once-through system with cooling towers will reduce direct zooplankton mortalities to about 24% of that incurred by the once-through system (to about 2.67 billion killed per June day). As discussed for the case of once-through cooling, one can presume on the basis of limited information that above 30% of zooplankton organisms pumped through the Palisades facility may be killed. This would presumably also be true for the 60,000 gpm pumped as diluent for cooling tower blowdown. There will also be about 15,000 gpm supplied through the service water system in which 100% of the organisms will be killed.

An additional source of damage to zooplankton is chlorination of cooling tower water and release of blowdown into the lake.

Zooplankton in the vicinity of the Palisades Plant can be expected to contain high concentrations of zinc derived from cooling tower blowdown such as to pass these high concentrations onto fish, and eventually to man.

Concentration factors of zinc averaged 5,000 times water concentration in invertebrates in the Columbia River.[97]

Zooplankton organisms appear to be more resistant to zinc toxicity than fish (see below). Reproduction of Daphnia magna was reduced at 0.10 ppm (water hardness = 45 ppm $CaCO_3$), while no effect was seen at 0.07 ppm.[106] Concentrations in water that are toxic for zooplankton will thus not occur, although possibilities of toxicity being exerted through the food chain, or effects of long-term buildup of zinc in Lake Michigan, cannot be excluded.

(c) Fish

Direct thermal effects upon fishes will be reduced by conversion to closed-cycle cooling, although heat input will not cease. Juveniles pumped in dilution water (60,000 gpm) will receive thermal shocks not much more than 5 F° above ambient rather than 25 or 28 F°. Plume temperatures will be lower in the maximally heated zone, and there will be a more rapid return to ambient temperatures. No mortality is expected due to thermal changes (see Appendix V-2).

There will be unavoidable mechanical damages to a few juvenile fish that may become pumped with dilution water. Any that enter the service water supply (which becomes the cooling tower makeup water) must be considered killed.

Chemical treatment of the cooling tower recirculating water, and subsequent release of portions of this water as blowdown, will subject fishes to a variety of chemicals. One of the most significant of these will be zinc. It will be released continuously in a concentration of 1.2 ppm which will be diluted to 0.036 ppm by the 60,000 gpm diluent flow prior to discharge. Its principal impacts will be through accumulation in food chains leading to man (see Table V-5) and its high toxicity to aquatic life (which will be especially significant after long-term buildup in the lake).

Zinc derived from cooling water blowdown will be concentrated in Lake Michigan fish and can be expected to pass these concentrations on to man should the fish be eaten (Table V-5). Zinc levels in Columbia River fish were 1,000 to 2,000 times levels found in the water.[97] Chronic release of zinc to Lake Michigan would constitute a serious environmental degradation if zinc concentrations in fish flesh reach levels that consititute a health hazard to man. There are no guidelines for environmental zinc at present. The drinking water standard for zinc is 5 ppm, established by the U.S. Public Health Service in 1964.[16]

Zinc is extremely toxic of fish.[98] In soft water, concentrations of zinc ranging from 0.1 to 1.0 ppm have been reported to be lethal. Calcium reduces zinc toxicity. For mature fish the lethal limit for zinc in water containing 1 ppm of calcium was 0.3 ppm, but in water with 50 ppm of calcium, as much as 2.0 ppm of zinc was not toxic.[98] The average calcium content of Lake Michigan waters is about 31 ppm.[94] Zinc is believed to exert its toxic action by forming insoluble compounds with the mucus that covers the gills, by damage to the gill epithelium, or possibly as an internal poison.

Sensitivity of fish to zinc varies with species, age, and condition of the fish as well as with the physical and chemical characteristics of the water.[98] The effects of zinc poisoning have been observed after fish received short exposures and then were returned to clean water. Salmon in the laboratory avoided water having a zinc concentration 1% of the median lethal concentration.[107]

Warm water temperatures decrease the survival time of trout in hard water, but the threshold concentration for toxicity and the 96-hour median tolerance limit are apparently not affected.

Applying this background information to the waters of Lake Michigan, the probable threshold of acute toxicity for representative adult fish may be about 1 ppm. This would, of course, vary with particular circumstances, but may be taken as reasonable.

The relationship between acutely toxic concentrations of zinc and concentrations that can be tolerated by an entire life cycle of a representative fish has been obtained by Brungs.[108] A chronic test in hard water (200 ppm as $CaCO_3$) involving fathead minnow reproduction determined the safe concentration of zinc to be between 0.03 ppm which had no effect, and 0.18 ppm which caused 83% reduction in eggs. Using the 4-day lethal concentration for 50% chances of death and 50% of survival (LC_{50}) of 9.2 ppm, the ratio of the above no-effect concentration to the LC_{50} is 0.0034. A test of 0.5% of the LC_{50} caused 20% reduction of eggs. From this, the best estimate of valid correction factor (or "application factor" as it is used by the Environmental Protection Agency[106] is close to 0.005. Previous analyses of data such as these suggested that 0.01 of the 96 hr LD_{50} dose is a safe concentration for continuous exposure.[106]

The safe level for zinc in Lake Michigan therefore may not be 1 ppm (as based on acute toxicity data alone) but rather about 0.005 ppm. This compares with 0.036 ppm that is planned for release at the Palisades discharge, and a normal lake concentration of about 0.01 ppm. The lake thus already exceeds levels deemed acceptable from available laboratory studies. The conclusions of both laboratory tests and the lake chemistry data are questionable, however, since both rely upon very few measurements. To add more zinc, in view of the present uncertainties, would seen to risk error on the side of environmental damage rather than on the side of safety. Zinc, unlike heat, is retained by the lake system and is not lost to the atmosphere. Thus, any substantial input of a toxic material contributes to the long-term degradation of water quality. This is particularly true in southern Lake Michigan where the flushing rate by inflowing water is extremely slow.[13]

d. Estimates of Damage

A gross estimate of damage to aquatic biota can be made as was done for the once-through system. Since the water used for the cooling tower design is only 60,000 gpm used to dilute the blowdown, the damage would be about 1/7 that for the once-through system or 8,500 pounds per year.

This estimate is only based on water use and does not take into account the lethal or sublethal effects of the chemicals present in the blowdown on aquatic biota or those in the drift on the terrestrial biota. Furthermore, the loss of water by evaporation (12,300 gpm) is not considered in estimating this cost of the adverse impact on Lake Michigan. The cooling tower structure may result in an adverse aesthetic effect which is difficult to quantify. (See discussion of cost-benefit analysis in Chapter XI.)

D. RADIOLOGICAL IMPACT ON MAN FROM ROUTINE PLANT OPERATION

During routine operation of the Plant at full power, small quantities of radioactive materials will be released to the environment. The Commission's licensing and inspection procedures will insure that the radiation dose received by persons living near the Plant will be as low as practicable in accordance with 10 CFR Part 50.36a and will be well within 10 CFR Part 20 limits. The staff has made calculations of the radiation dose using estimates of release rates of radionuclides to the environs and using stated assumptions relative to dilution, biological reconcentration in food chains, and "use factors" by people.

The radiation dose estimates from radioactive effluents were calculated on the basis of concentrations which the staff estimates will be released from the Plant. These concentrations differ from those used in the applicant's Environmental Report and are the result of limiting conditions for operations which will be a part of the initial Technical Specifications applying to the Plant. (See Section IIID.2.)

The liquid waste effluents will be mixed with the once-through condenser coolant water which is pumped at a rate of approximately 405,000 gpm from the intake on Lake Michigan and discharged back into Lake Michigan.

The gaseous radwaste effluents is released from vents located about 200 feet above grade on the containment building. Dilution of the gaseous effluent will occur by diffusion and turbulent mixing as the plumes are carried by the winds.

Estimates have been made of the anticipated exposure of persons to radiation from the Palisades Plant. The radiation dose estimates are based upon the postulated release of radioactive material, presented in Tables III-7 and III-8, the population distribution, the various dispersion modes applicable for the area, and the normal activities which determine the degree of intake or exposure to the individuals. Specific data on meteorology and hydrology are presented in Section II.E and the population distribution is presented in Section II.C of this Statement. 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 through ecological chains by the effluents and from breathing air containing effluents.

The applicant has made an agreement with a group of intervenors to make two significant modifications to the Palisades Plant within two years of beginning operations. The first of these is to augment the liquid radwaste system so that (except for laundry wastes) all liquids in the radwaste system will be recycled back into the cooling systems and radioactive material removed in processing the liquids will be converted to solid form for removal from the Plant. This modification will result in less activity discharged in liquid effluents but increase the tritium content in gaseous effluents. This augmented system will reduce the liquid waste radioactivity to levels at or below those in the Commission's proposed Appendix I to 10 CFR Part 50.

The second modification planned is the installation of closed cycle mechanical draft cooling towers and a recirculating condenser cooling system to replace the present once-through cooling system. Some exchange of the recirculating coolant and the lake water will be necessary to limit the buildup of solids in the coolant by evaporation. The effect of using the recirculating condenser cooling-tower system will be to reduce the volume of liquid effluent discharged into Lake Michigan without affecting the amount of radionuclides released, e.g., the concentrations at the point of discharge will be increased.

This Statement addresses only the radiological impact of the original Plant design. Three other possibilities exist: (1) once-through condenser cooling with the modified liquid radwaste system; (2) recirculating condenser cooling with the initial liquid radwaste system; and (3) recirculating condenser cooling with the modified liquid radwaste system. Compared to the condition evaluated in this Statement, the first and third combinations would result in lesser radiological impact from the release of liquid effluents and the second combination would result in a greater impact (by perhaps a factor of 7) at the discharge point. However, the second and third combination would result in a slightly greater radiological impact from the release of tritium in gaseous effluents. In view of the small radiological impact anticipated from the original Plant design (i.e., once-through condenser cooling and initial liquid radwaste system) evaluated herein and the uncertainties in final design, a complete evaluation of the alternatives has not been included in this Statement.

Two additional nuclear power stations (Donald C. Cook No. 1 and No. 2) are to be constructed by another utility (Indiana and Michigan Electric Co.) at Bridgman, Michigan, approximately 30 miles south of the Palisades site. The radiological impact of nuclear stations other than Palisades Plant is not addressed in this Statement.

1. Impact of Liquid Releases

The radiation doses to persons who drink water affected by the Plant are listed in Table V-5. The whole body dose to an individual eating 50 grams of fish per day, caught at the cooling water discharge was estimated to be 2.8 mrem per year. The bioaccumulation factors used in these calculations are given in Table V-10. The same amount of fish would result in a thyroid dose to the individual of 1 mrem per year. The whole body external dose to persons swimming 100 hr. per year in the liquid effluent at the point of discharge was calculated and found to be 0.006 mrem per year, and a person fishing at that location for 500 hours per year would receive 0.014 mrem. Radionuclides suspended in the lake water tend to be adsorbed onto bottom sediments which constitute a potential source of exposure to persons standing along the shoreline. Assuming that an individual were to spend 500 hours per year on the beach near the reactor discharge, the annual dose would be about 0.12 mrem.

2. Impact of Gaseous Releases

The radiation doses to persons who are exposed to gaseous effluents from the Plant are listed in Table V-6. The nearest potential grazing land of the Plant is located 2 miles from the Plant in the SSE sector. There are presently no cows at that location. Should a cow be located there at some later date, the dose to a child's thyroid from drinking one liter of milk per day from that cow would be 2.5 mrem per year.

3. Radiation Dose to the General Population

The cumulative population, cumulative population whole body dose, and average whole body dose from gaseous effluents (noble gases) for various radial distances from the Palisades Plant are presented in Table V-7. The internal whole body dose to the approximately 46,500 persons who may get all of their drinking water from Lake Michigan is estimated to be 0.30 man-rem per year. Table V-7 lists the water supply data used in making this estimate. There are uncertainties about local fish catches, e.g., specific location and amount. However, a conservative estimate can be made, assuming that each of the 1,000,000 persons within a 50-mile radius of the Plant eats 20 grams per day of fish from Lake Michigan, and the average fish lives in water diluted by a factor of 1,000 from the canal concentration. This calculation results in a whole body dose to the population of 1.1 man-rem.

TABLE V-6

ANNUAL AVERAGE DOSES TO INDIVIDUAL AT
THE MOST SIGNIFICANT LOCATIONS NEAR PALISADES

Location	Pathway	Whole Body Dose mrem	Thyroid Dose* mrem
Boundary	Cloud	0.57	--
Nearest Dairy Farm	Ingestion of milk**	--	1.3
Boundary	Inhalation	--	1.0
Discharge Point	Ingestion of water***	0.06	6.4
South Haven, Michigan	Ingestion of water	0.022	1.4
Benton Harbor) Benton Central) South Benton,) Michigan)	Ingestion of water	0.00064	0.42
St. Joseph, Michigan	Ingestion of water	0.00060	0.40

*Doses to the G.I. tract were also calculated but they were found to be much less than the thyroid doses.

**Assumes a child drinks fresh milk derived solely from a cow grazing 5 months of the year at a point 3 miles from the Plant in the SSE sector.

***Assumes an individual obtains one-fourth of his drinking water at the discharge point.

TABLE V-7

ESTIMATED CUMULATIVE POPULATION, ANNUAL MAN-REM DOSE AND AVERAGE ANNUAL DOSE FROM GASEOUS EFFLUENT IN CONCENTRIC CIRCULAR AREAS AROUND PALISADES PLANT

Radius (miles)	Cumulative No. of People (1971)	Cumulative Dose (man-rem)	Average Dose mrem/person
1	52	0.0061	0.12
2	325	0.014	0.056
3	1,800*	0.028	0.015
4	3,800	0.042	0.011
5	5,900	0.053	0.0080
10	30,000	0.12	0.0041
20	130,000	0.22	0.0017
30	220,000	0.27	0.0012
40	530,000	0.36	0.00067
50	1,000,000	0.57	0.00057

*The population and dose figures have been calculated to account for an estimated 2,000 persons per day for three months (equivalent to 500 persons/year) at campsites and other recreational sites within a three-mile radius of the Palisades Plant.

TABLE V-8

MUNICIPAL DRINKING WATER SUPPLY INTAKE DATA
(WITHIN 50 MILES RADIUS OF PALISADES PLANT)

Municipality	Distance (miles)	Population (1970)	Estimated Dilution Factor
South Haven, Michigan	5	6,471	1:110
Benton Harbor) Benton Central) South Benton,) Michigan)	17	29,044	1:375
St. Joseph, Michigan	18	11,042	1:398

4. Radiological Environmental Monitoring Program

The applicant began preoperational monitoring surveillance programs in June 1968 to determine the background levels of radioactivity in the vicinity of the Palisades Plant. This program has continued since that date. Samples of airborne particulates, lake water, well water, milk, fish, food crops, aquatic biota, soil, and lake sediments are collected and analyzed for their radionuclide content. In addition to this program, the applicant, along with other parties, has sponsored extensive programs carried out by the Great Lakes Research Division, University of Michigan, to study the radioactivity in Lake Michigan and its flora and fauna. The post-operational survey program proposed by the applicant is basically a continuation of the preoperational program and is given in detail in the Final Safety Analysis Report. (See Table V-9.) This program will be amplified and further defined in the Technical Specifications for the Plant.

5. Evaluation of Radiological Impact

In assessing the total radiological impact of the Palisades Plant, a comparison should be made with the annual average radiation dose from natural "background" sources which is about 0.1 rem to the individual. This source results in a total dose of 100,000 man-rem. Thus, operation of the Palisades Plant will contribute only an extremely small increment (about 3.0 man-rem) to the radiation dose that area residents receive from natural background. Since fluctuations of the natural background dose may be expected to exceed the small dose increment contributed by the Plant, this increment will be unmeasurable in itself and will constitute no demonstrable meaningful risk to be balanced against the benefits of the Plant.

E. RADIOLOGICAL IMPACT TO ORGANISMS OTHER THAN MAN

This section contains a description of the radiation dose calculations and an assessment of the doses to aquatic and terrestrial organisms in the vicinity of the Palisades Plant. Operating conditions under which radionuclide releases to air and water will occur have been described in Section III.D.

1. Terrestrial Environment

Because of the many potential modes and pathways of radiation exposure to terrestrial organisms near the Palisades Plant, a single pathway was selected which would most likely result in the maximum radiation dose to an organism in the surrounding terrestrial

TABLE V-9

PALISADES ENVIRONMENTAL MONITORING PROGRAM

SPECIFIC SAMPLES AND COLLECTION FREQUENCY

Sample Class	Collection Frequency	Number of Samples to be Collected Palisades: Preoperational	Number of Samples to be Collected Palisades: Operational
Air	Weekly	5	12
Lake Water	Monthly	1	2
Well Water	Monthly	3	3
Milk	Monthly	4	4
Organic	Monthly in Season	Crops and Fish as Desired	Crops and Fish as Desired
Film or TLD	Monthly	5	12
Film or TLD	Quarterly	5	12

ecosystem. In terms of producing the maximum dose, this exposure pathway would be for an animal such as a duck or muskrat, etc., which consumes aquatic plants (algae etc.) that are growing in the water near the point of discharge of liquid radioactive effluents. Although other pathways were considered, this one was selected for assessment based on the following: (1) Estimated dose to man from (a) submersion in air (external dose), (b) ground contamination (external dose), and (c) inhalation (internal thyroid dose) resulted in a dose of only 0.4 mrem/year based on the worst-case condition (Section V.D). The dose to these terrestrial animals would be approximately the same. (2) If a second internal dose from ingestion of contaminated terrestrial plants was added to this dose of 0.4 mrem/yr, the dose would be raised only slightly because terrestrial plants do not concentrate nuclides from gaseous releases at nuclear power reactors. (3) Since algae concentrate most radionuclides by factors usually ranging from approximately 10^2 to 10^5 relative to the concentrations in water, the internal radiation dose to a wild animal consuming aquatic plants would probably be much greater than for terrestrial animals having other food chain pathways.

To assess the potential effect from a combined aquatic-terrestrial pathway, the internal dose to the whole body was estimated for a mammal or bird eating algae or other aquatic plants as its only source of food. The ratio of daily intake (grams of algae consumed) to total body weight (grams of animal) was set equal to 0.1, and the animal was assumed to be in equilibrium with the algae (i.e., the animal had attained an equilibrium body burden of radionuclides such that the rate of excretion equalled the rate of assimilation). Concentrations of radionuclides in the algae were computed as the product of the radionuclide concentration in effluent water at the point of discharge from the Palisades Plant and the concentration factor (radionuclide concentration in organism at equilibrium per unit wet weight divided by radionuclide concentration per ml of water in which the organism is growing) for that nuclide.

The internal dose, D_i (mrad/year), for the i^{th} radionuclide to an animal consuming aquatic plants was computed from the following equation:

$$D_i = \frac{1.87 \times 10^7 \times X_i^{eq} E_i}{m} , \qquad (1)$$

where 1.87×10^7 is a constant to convert μCi/g of animal to mrad/year, X_i^{eq} is the body burden of the i^{th} radionuclide (μCi) at equilibrium in an animal consuming 100g of algae per day, E_i is the effective absorbed energy (Mev) of the i^{th} radionuclide for a 10 cm-diameter-cylindrical shaped animal, and m is the mass of the animal (1,000g). The body burden, X_i^{eq} (μCi), of the i^{th} radionuclide at equilibrium in the total body of the animal was computed from the following expression:

$$X_i^{eq} = 1.4\ T_i\ W_i\ C_i\ g\ f_i, \qquad (2)$$

where T_i is the effective half-time (days) of the i^{th} radionuclide in the whole body of the animal, W_i is the concentration (μCi/ml) of the i^{th} radionuclide in the liquid effluent of the Palisades Plant, C_i is the concentration factor of the i^{th} radionuclide in algae or other aquatic vegetation (dimensionless), g is the mass (grams) of algae consumed per day (100 g/day) by the animal, and f_i is the fraction of the ingested quantity of radionuclide "i" that is initially assimilated by the tissues of the animal (dimensionless).

The estimated total internal dose to an animal from the given pathway of exposure was 16 rad/year or approximately 44 rad/day. Cesium-134 and ^{137}Cs contributed 99.9% of this dose.

Literature on the effects of chronic low-level radiation on terrestrial biota is not extensive. French[133] found a suggested shortening of life span in pocket mice, induced by 0.9 rad/day chronic gamma radiation. Available information indicates that a detectable radiation effect would not be found at a dose rate of 16 rad/yr for terrestrial animals.

It must be emphasized, however, that doses to these animals represent extreme conditions, i.e. the organisms are assumed to feed only on aquatic plants which are growing in a relatively small area near the discharge structure. If they consume foods other than these aquatic plants, or feed in areas other than the immediate area of the discharge where radionuclide concentrations in algae will be lower, the doses will decrease significantly. Also, it is highly unlikely that a mammal or bird would feed only in this one location for a period of time sufficient to attain equilibrium with radionuclides in aquatic plants.

Although the pathway of exposure to terrestrial organisms which was selected is realistic since shore birds and waterfowl are known to feed in the inshore areas near the Palisades Plant, the estimated dose is maximized because of the assumptions we have used. In spite of this, the maximum dose is far lower than the dose necessary to produce a detectable effect.

2. Aquatic Environment

Although concentrations of radionuclides in liquid effluents will be diluted in Lake Michigan, the ability of organisms to concentrate these materials presents a potential radiological hazard to species living in the contaminated water. In Table V-10 bioaccumulation factors for radionuclides in fresh water biota are given.[134] In order to assess the potential impact of liquid releases to Lake Michigan biota, radiation doses to aquatic plants (algae etc.), invertebrates, and fish were calculated. Dose calculations were based on the assumption that the organisms live continuously in effluent water containing radionuclides in concentrations equal to those at the point of discharge from the Palisades Plant (i.e. before dilution with Lake Michigan water). This pathway of exposure was used in order to maximize estimated doses. Organisms living out in the lake will receive a lower dose as radionuclide concentrations become diluted with Lake Michigan water.

Total doses were computed as the sum of the immersion (β and γ) and internal dose. The internal dose to aquatic organisms results from intake of radionuclides through either ingestion (food chain), direct absorption from water, or both. Immersion dose results from immersion of the organism in the contaminated water.

Internal dose, D_i (mrad/year), for the i^{th} radionuclide was computed from the following equation:

$$D_i = 1.87 \times 10^7 \, W_i \, C_i \, E_i, \qquad (3)$$

where 1.87×10^7 is a constant to convert μCi/g of organism to mrad/yr, W_i is the concentration (μCi/ml) of the i^{th} radionuclide in the liquid effluents of the Palisades Plant, C_i is the concentration factor of the i^{th} radionuclide in the biota of interest, and E_i is the effective absorbed energy (MeV) of the i^{th} radionuclide (the largest effective absorbed energy listed in Report No. 2 of the International Commission for Radiation Protection[135] was selected).

Immersion doses in water were computed with the EXREM computer code[136,137]. This calculation assumes continuous immersion of the organism in water.* Both the internal and immersion dose calculations assume steady-state conditions (i.e. the radionuclide concentrations in water remain constant).

The computed internal doses are maximized since the maximum effective absorbed energies (E_i) in man were used in the

*Water contains radionuclides as indicated in Chapter III, Table III-8.

Table V-10

Bioaccumulation Factors for Radionuclides

In Freshwater Biota

Radionuclide	Reconcentration Factors Fish	Invertebrates	Plants
H-3	0.93	0.93	0.93
Cr-51	200	2,000	4,000
Mn-54-56	25	40,000	10,000
Fe-55-59	300	3,200	5,000
Co-58-60	500	1,500	1,000
Rb-86	2,000	2,000	1,000
Sy-89-90	40	700	500
Y-91	100	1,000	10,000
Zn-95	100	1,000	10,000
Nb-95	30,000	100	1,000
Mo-99	100	100	100
Ru-103-106	100	2,000	2,000
Te-129m-132	400	150	100
I-131-132-133-135	1	25	100
Cs-134-137	1,000	1,000	200
Ba-140	10	200	500
Ce-141-144	100	1,000	10,000
Nd-147	100	1,000	10,000
Pm-147	100	1,000	10,000

calculation. For small organisms such as single-celled phytoplankton, zooplankton, benthic invertebrates, etc., the internal dose will tend to be over-estimated because these organisms will not absorb this amount of energy emitted from a radionuclide deposited in the body or cells of the species.

Immersion doses to benthic (bottom living) organisms such as invertebrates and periphytic algae, are probably underestimated since a source term from radionuclides sorbed onto inorganic and organic bottom sediments was not included in the dose calculation.

There are virtually no organic sediments in the near-shore waters of the Palisades Plant and sorption of most radionuclides onto inorganic sediments is greatest when clay minerals with a high cation exchange capacity are present[138,139]. Sorption of ^{137}Cs onto silica sand, which is the dominant sediment type in the area of the Palisades Plant,[140] would be over two orders of magnitude less than on clay sediments.[141] Kolehmainen et al.[142] found that the removal rate of ^{137}Cs from water by nonbiotic factors was slow in lakes with no clay turbidity (i.e., ^{137}Cs remained in solution). In the near shore areas of Lake Michigan, clay turbidity is low except during storms when turbidity increases in some areas as a result of waves exposing the clay till which underlies the sand in near-shore areas. Most of the time, radionuclides in the liquid effluent will probably remain in solution and be rapidly diluted and dispersed in Lake Michigan rather than concentrating on sediments near the Plant discharge. Thus, the external dose to benthic species from sediments should not be significantly different from the computed for immersion in water only.

Concentration factors (C_i) used in the calculation of internal dose (Table V-10) were experimentally determined values obtained from the literature since there were not data on concentration factors specifically for the Lake Michigan ecosystem. Because factors vary in different environments due to various physical, chemical, and biological conditions, the maximum values for freshwater ecosystems obtained from the literature were used in most of the calculations.

The radionuclide concentrations in effluent water are based on several assumptions of Plant operation which tend to maximize radionuclide concentrations in effluent water based on comparisons with actual operating histories of other plants.

The estimated total doses (internal plus immersion) for aquatic plants, invertebrates, and fishes living in the discharge canal are 11, 7, and 4 mrad/day, respectively. Most of this dose in all organisms is from internal exposure. The nuclides of cesium and ^{91}Y contribute most of the internal dose in plants, invertebrates, and fish.

These doses are below those at which demonstrable radiation effects to aquatic organisms have been found. The problem of detecting effects at low dose levels such as these which result from radionuclide releases at nuclear power reactors was pointed out in two recent reviews[143,144] and can be summarized as follows:

> "In assessing the effect of low doses of ionizing radiation, sophisticated means of detection must be used and sensitive biological endpoints are necessary as criteria for ascertaining radiation damage. In experimental practice when dose rates are lowered to 1 rad/per day or less, the number of factors affecting the organism are sufficient to mask any effects that might be present. Such commonly used endpoints as survivorship, fecundity, growth, development, and susceptibility to infection have not as yet been shown to be unequivocally affected by such low dose rates."[143]

Since the assumptions used to estimate doses to aquatic organisms near the Palisades Plant tend to maximize the dose, but are still less than 1 rad per day, there should be no radiation effects to these organisms as a result of the low-level releases.

In summary, assessment of the effects of radioactive releases to organisms other than man shows that most terrestrial animals living on the Plant site would receive a dose only slightly greater than man (based on the worst-case conditions for each). The dose would be far below that for which discernible radiation effects have been found. Some terrestrial animals (e.g., ducks) which consume algae growing in the immediate area of the plant discharge could receive a higher dose. It is unlikely, however, that ducks or other terrestrial organisms known to feed on aquatic plants would continuously feed only on algae in this small area for a period long enough to obtain a radiation dose that would produce discernible effects. Radiation doses to aquatic plants and animals living in the immediate area of the Palisades Plant were calculated and found to be far below those for which demonstrable radiation effects have been found. Thus, release of radionuclides from Palisades Plant to the environment should have no impact on either terrestrial or aquatic organisms in the area.

F. TRANSPORTATION OF NUCLEAR FUEL AND SOLID RADIOACTIVE WASTE[109]

1. Routine Transportation Procedures

The applicant in its "Supplemental Information on Environmental Impact of the Palisades Plant,"[109] of November 3, 1971, describes its procedures for transporting fuel and solid wastes. The nuclear fuel for the Palisades Plant is uranium enriched in U-235 over a range of from 1.65 to 3.20% by weight, with the average being 2.74%. The fuel is in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. Each fuel element is made up of 212 fuel rods about 12 feet long. Each year in normal operation, about 68 fuel elements are replaced.

The applicant[109] has indicated that cold fuel for the reactor will be transported by truck to the Plant site. The applicant has indicated the source of the cold fuel to be Combustion Engineering, Inc., and the Jersey Nuclear Company; we have assumed an average shipping distance of 850 miles. Solid wastes and irradiated fuel will be transported by truck or rail. We have assumed a distance of 700 miles for shipping the irradiated fuel and 500 miles for shipping the solid radioactive wastes.

a. Transport of Cold Fuel

The applicant has indicated that cold fuel will be shipped in Commission and Department of Transportation- (DOT) approved containers which hold two fuel elements per container. About 5 truck loads of 8 containers each will be required each year.

b. Transport of Irradiated Fuel

Fuel elements removed from the reactor will have been irradiated to about 24,000 megawatt thermal days per ton (MW(t)-d/T) on the average; they will be unchanged in appearance and will contain much of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of radioactivity, mostly 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 discharge from the reactor. After discharge 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 applicant states that the irradiated fuel elements will be shipped in approved casks designed for transport by either truck or rail. The cask will weigh perhaps 25 tons for truck or 50 tons for rail. To transport the irradiated fuel, the applicant estimates 20 truck load shipments. We estimate 10 railcar load shipments per year. An equal number of shipments will be required to return the empty casks.

c. Transport of Solid Radioactive Wastes

The applicant estimates that the solid radioactive wastes generated by the reactor will amount to approximately 2100 ft^3/yr. and will require the shipment of from 6 to 9 truck loads or 1 to 3 railcar loads of packaged wastes each year. This will be shipped probably to Illinois for disposal. The wastes will be shipped in 55-gallon drums or other packages approved for the transport of the activities involved. Compressible wastes will be compacted in 55-gallon drums; other wastes will be solidified by a method such as mixing with concrete.

2. Transportation Accidents[109]

a. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste, described in Section F.1, 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 move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive cargo. The shipper has essentially no control over the likelihood of an accident involving his shipment. Safety in transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated at the Federal level by both the Atomic Energy Commission (AEC) in 10 CFR 70 and 71 and the Department of Transportation (DOT) in 49 CFR 170-179. 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 is 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. The packaging may release its contents in an accident.

For larger quantities of radioactive materials, the packaging design (Type B packaging) must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.[110]

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 fresh 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,[111] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every 6 years. In case of an accident, procedures with carriers are required[111] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and the DOT. 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.

b. <u>Exposures During Normal (No Accident) Conditions</u>

(1) <u>Cold Fuel</u>

The transport of cold fuel for the Palisades Plant has been described in Section F.1.a. Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 mrem per shipment. For the 5 shipments, with two drivers for each vehicle, the total dose would be about 0.01 man-rem* per year. The radiation level associated with each truck load of cold fuel will be less than 0.1 mrem/hr at

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*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 brakeman) 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).

6 feet from the truck. A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of about 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

(2) Irradiated Fuel

Irradiated fuel from the reactor at Palisades will be transported either by truck or by rail. Based on actual radiation levels associated with shipments of irradiated fuel elements, we estimate the radiation level at 3 feet from the truck or rail car will be about 25 mrem/hr. The individual truck driver would be unlikely to receive more than about 30 millirem in the 700-mile shipment. For the 20 shipments by truck during the year with 2 drivers on each vehicle, the total dose would be about 1 man-rem per year.

Train brakemen might spend a few minutes in the vicinity of the car at an average distance of 3 feet, for an average exposure of about 0.5 millirem per shipment. With 10 different brakemen involved along the route, the total dose for 10 shipments during the year is estimated to be about 0.05 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck or rail car, might receive a dose of as much as 1.3 mrem per shipment. If 10 persons were so exposed per shipment, the total annual dose for the 20 shipments by truck would be about 0.3 man-rem and for the 10 shipments by rail, about 0.1 man-rem. Approximately 200,000 persons who reside along the 700-mile route over which the irradiated fuel is transported might receive an annual dose of about 0.4 man-rem if transported by truck, and 0.2 man-rem if transported by rail. The regulatory radiation level limit of 10 mrem/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 of the shipping route. It was assumed that the shipment would travel 200 miles per day and the population density would average 330 persons per square mile along the route.

The amount of heat released to the air from each cask will vary from about 30,000 Btu/hr for truck casks to about 250,000 Btu/hr for rail casks. For comparison, 35,000 Btu/hr is about equal to the heat released from an air conditioner in an average-sized home. Although the temperature of the air which contracts 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.

(3) Solid Radioactive Wastes

As noted in Section F.1.c, about 9 truck loads or 3 railcar loads of solid radioactive wastes will be shipped from Palisades 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 the 9 truck loads in a year, he could receive an estimated dose of about 140 mrem during the year. A total dose to all drivers for the year, assuming 2 drivers per vehicle, might be about 0.3 man-rem.

Train brakemen might spend a few minutes in the vicinity of the car at an average distance of 3 feet, for an average exposure of about 0.5 millirem per shipment. With 10 different brakemen involved along the route, the total dose for the 3 shipments during the year is estimated to be about 0.02 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck or rail car might receive a dose of as much as 1.3 mrem per shipment. If 10 persons were so exposed per shipment, the total annual dose for the 9 shipments by truck would be about 0.1 man-rem and for the 3 rail shipments, about 0.04 man-rem. Approximately 60,000 persons who reside along the 200 mile route over which the solid radioactive waste is transported might receive an annual dose of about 0.2 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, 10 mrem/hr at 6 feet from the vehicle, and the shipment traveling 200 miles per day.

G. PLANT 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 reasonably assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the Plant down and maintaining it in a safe condition. It is expected that the applicant will supply detailed dismantling information to the Commission at such time that an application for an operating license is filed. The staff will at that time conduct a Safety Evaluation of the decommissioning procedures proposed by the applicant.

1. Impacts on the Environment

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

It is expected that the dismantling of the Plant will cost several millions of dollars and take more than a year to complete. During that time, workmen will be on the site, quantities of debris, salvageable material, and radioactive material will be transported from the site by truck, barge, or rail. Concrete and other construction materials will be used to entomb the reactor and associated highly radioactive components. A considerable amount of earth-moving will be required to restore the parking lots and other areas to usable grade levels, and finally, a security fence will be erected on the ground above the entombed reactor site.

To the extent that the proposed mechanical-draft cooling towers are not completely demolished and its foundations removed, that small amount of land will be committed to non-productive use. If the soil under any structure which has been demolished is not replaced or cleared of chemical contamination, that land will be non-productive until natural processes leach the chemicals away.

The overall impact of dismantling the Plant will be beneficial to the environment, since the objective of that proposed action is to restore most of the Plant's acreage to ecological productivity. However, the applicant has already landscaped the majority of his site such as to protect the unique natural resources - the sand dunes - from wind erosion.

2. Radiological Impacts on Environment

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

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 as a radioactive area.

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 Plant down and maintaining it in a safe condition, it is expected that the proposed action will have no significant radiological impact on the environment.

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VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents in the Palisades Plant is provided through correct design, manufacture, and operation, and the quality assurance program used to establish the integrity of the reactor system, as considered in the Commission's Safety Evaluation dated March 6, 1970 and Supplements to the Safety Evaluation. Deviations that may occur are handled by protective systems to place and hold the Plant in a safe condition. Notwithstanding this, serious accidents might occur, in spite of the fact that they are extremely unlikely and engineered safety features are installed to mitigate the consequences of these events.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from a radiological effects standpoint have been analyzed using best estimates of probabilities and realistic fission product release and transport assumptions. In the Commission's safety review, conservative assumptions were used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel against the 10 CFR 100 siting guidelines.[1] The computed doses that might be received by the population from actual accidents should be less than those presented in the Commission's Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971, requiring the consideration of a spectrum of accidents with realistic assumptions. The applicant's response is contained in the "Supplemental Information on Environmental Impact of the Palisades Plant," dated November 3, 1971.

The applicant's report has been evaluated, using the Commission's standard accident assumptions and guidance issued as a proposed Annex to Appendix D of 10 CFR 50 by the Commission on December 1, 1971.[2] Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high consequence end of the spectrum have a low occurrence rate, and those on the low consequence end have a higher occurrence rate. The examples selected by the applicant for these classes are shown in Table VI-1. The examples selected are reasonably homogeneous in terms of probability

TABLE VI-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	AEC DESCRIPTIONS	APPLICANT'S EXAMPLE(S)
1	Trivial Incidents	Not Considered - Trivial Consequences
2	Miscellaneous Small Releases Outside Containment	Abnormal Auxiliary System Leak
3	Radwaste System Failures	Waste Gas Decay Tank Relief Valve Leak
4	Events that Release Radioactivity Into the Primary System	Not Applicable
5	Events that Release Radioactivity Into Secondary System	Normal Operation with Fuel Failures and Steam Generator Leaks
6	Refueling Accidents Inside Containment	Damaged Fuel Assembly
7	Accidents to Spent Fuel Outside Containment	Damaged Fuel Assembly
8	Accident Initiation Events Considered in Design-Basis Evaluation in the Safety Analysis Report	Rod Ejection Accident Loss of Load with Off-site Power Available Double-Ended Main Stem Line Break Steam Generator Tube Rupture Waste Gas Decay Tank Rupture Loss-of-Coolant Accident
9	Hypothetical Sequences of Failure More Severe than Class 8	Not Considered - Extremely Small Probability of Occurrence

within each class, although the staff considers the release of the waste gas decay tank as more appropriately in Class 3 and the loss of load incident and the steam generator tube rupture as more appropriately in Class 5.

Certain assumptions made by the applicant, such as the iodine partition factors and the omission of the primary coolant source in secondary system accidents, are questionable; but the use of alternative assumptions does not significantly affect the overall environmental and radiological consequences.

The staff's estimates of the annual dose which might be received by an individual assumed to be standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table VI-2. Estimates of the man-rem dose that might be delivered to the population within 50 miles of the site are also presented in Table VI-2. The man-rem dose estimate is based on the projected population of about 1,180,000 within 50 miles of the site for the year 1980.

To establish a realistic annual risk of exposure, the estimated doses in Table VI-2 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 and some steam generator leakage, 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 VI-2 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 in 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 the associated 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 a high degree of assurance that potential accidents in this class are, and will remain, sufficiently low in probability so that the associated risk is extremely low.

TABLE VI-2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary 1/	Estimated Dose to Population in 50-Mile Radius, man-rem 3/
1.0	Trivial Incidents	2/	2/
2.0	Small Releases Outside Containment	2/	2/
3.0	Radwaste System Failures		
3.1	Equipment Leakage or Malfunction	0.056	2.3
3.2	Release of Waste Gas Storage Tank Contents	0.22	9.0
3.3	Release of Liquid Waste Storage Tank Contents	0.003	0.1
4.0	Fission Products to Primary System (BWR)		
4.1	Fuel Cladding Defects	N.A.*	N.A.*
4.2	Off-Design Transients that Induce Fuel Failures above Those Expected	N.A.*	N.A.*
5.0	Fission Products to Primary and Secondary Systems (PWR)		
5.1	Fuel Cladding Defects and Steam Generator Leaks	2/	2/
5.2	Off-Design Transients that Induce Fuel Failure above Those Expected and Steam Generator Leak	0.001	<0.1
5.3	Steam Generator Tube Rupture	0.074	3.0

TABLE VI-2 (cont'd)

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary[1]	Estimated Dose to Population in 50-Mile Radius, man-rem[3]
6.0	Refueling Accidents		
6.1	Fuel Bundle Drop	0.012	0.47
6.2	Heavy Object Drop onto Fuel in Core	0.20	8.2
7.0	Spent Fuel Handling Accident		
7.1	Fuel Assembly Drop in Fuel Storage Pool	0.007	0.30
7.2	Heavy Object Drop onto Fuel Rack	0.03	1.2
7.3	Fuel Cask Drop	N.A.*	N.A.*
8.0	Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report		
8.1	Loss-of-Coolant-Accidents		
	Small Break	0.12	9.0
	Large Break	0.90	220
8.1(a)	Break in Instrument Line from Primary System that Penetrates the Containment	N.A.*	N.A.*
8.2(a)	Rod Ejection Accident (PWR)	0.09	22
8.2(b)	Rod Drop Accident (BWR)	N.A.*	N.A.*

TABLE VI-2 (cont'd)

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary 1/	Estimated Dose to Population in 50-Mile Radius, man-rem 3/
8.3(a)	Steamline Breaks (PWR's Outside Containment)		
	Small Break	<0.001	<0.1
	Large Break	<0.001	<0.1
8.3(b)	Steamline Breaks (BWR)		
	Small Break	N.A.*	N.A.*
	Large Break	N.A.*	N.A.*

1/ Represents the calculated fraction of a whole body dose of 500 mrem or the equivalent dose to an organ.

2/ These releases will be comparable to the design objectives indicated in the proposed Appendix I to 10 CFR 50 for routine effluents (i.e., 5 mrem/year to an individual from all sources).

3/ Based on 1960 census population data increased by 36% to be representative of the 1980 population (as estimated by the applicant).

* Not Applicable.

Table VI-2 indicates that the estimated radiological consequences of the postulated accidents could result in exposures to individuals assumed to be living at the site boundary to concentrations of radioactive materials within the Maximum Permissible Concentrations (MPC) of Table II, Appendix B of 10 CFR 20. Table VI-2 also shows that the estimated man-rem dose of the population within 50 miles of the Plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 118,000 man-rem/yr based on a natural background level of 0.1 rem/yr for a population estimated to be 1,180,000 by 1980. When considered with the probability of occurrence, the potential annual radiation exposure of the population from all the postulated accidents is an even smaller fraction of exposure than that from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of this analysis that the radiological risks to the environment due to postulated accidents during operation of the Palisades Plant at full power are extremely small. Discussion of the comments from Federal agencies on the environmental impact from postulated accidents as described in the Draft Detailed Statement is presented in Chapter XII.

B. TRANSPORTATION ACCIDENTS

1. Cold Fuel

The cold fuel to be transported to Palisades has been described in Section F.1.a. The applicant[3] describes the procedures for transporting fuel and solid wastes and the exposures to the public resulting from postulated accidents involved during transportation. Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and the low specific activity of the fuel, limit the radiological impact 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 assemblies 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 extremely remote. If criticality were to occur in transport, 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 and normally would not recur. 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.

2. Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel (see Section F.1.b) have been estimated for the situation where any contaminated coolant is released and the situation where gases and coolant are released.

a. 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. Such an accident is highly 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 is about the smallest amount of leakage that can be detected by visual observation of a large container. If undetected leakage of contaminated liquid coolant were to occur, the amount would be so small that the individual exposure would not exceed a few millirem and only a very few people would receive such exposures.

b. 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 assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

In such an accident, the amounts 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[4] of the Environmental Protection Agency. The Department of Transportation in its regulations in 49 CFR 170-179[5] also outlines procedures used when a spilled shipment might occur. Some of these procedures are presented in Section V.F.2.a. Discussion of the comments from Federal agencies on transportation accidents is presented in Chapter XII.

3. Solid Radioactive Wastes

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the Plant. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some releases 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 radioactive waste will be shipped in Type B packages. 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 case, spread of the contamination beyond the immediate area is unlikely and, although local cleanup might be required, no significant exposure to the general public would be expected to result.

a. Severity of Postulated Transportation 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 ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk and radiological consequences are extremely low. For those reasons, more severe accidents have not been included in the analysis.

b. Alternatives to Normal Transportation Procedures

Alternatives, such as special routing of shipments, 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 Plant, have been examined. 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.

References for Chapter VI

1. Title 10, Code of Federal Regulations, Part 100 - Reactor Site Criteria.

2. Title 10, Code of Federal Regulations, Part 50 "Licensing of Production and Utilization Facilities - Consideration of Accidents in Implementation of the National Environmental Policy Act of 1069", Federal Register, Vol. 36, No. 231, December 1, 1971.

3. Consumers Power Company, "Supplemental Information on Environmental Impact of the Palisades Plant - November 3, 1971."

4. Federal Radiation Council Report No. 7.

5. Department of Transportation, Title 49, Code of Federal Regulations, Part 170-179, including 49 CFR § 171.15, 173.398, 174.566, 177.861; the Atomic Energy Commission, Title 10, Code of Federal Regulations Part 71.36. "Packaging of Radioactive Material for Transport."

VII. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

The Palisades Plant occupies 30 acres of the 487-acre site, with another 2.3 acres of the sand dunes to be occupied in the future by the mechanical draft cooling towers. Wind erosion, particularly during the winter when ice will be melted by the thermal discharge, may cause some disturbance of the sandy beach but the damage should be limited to the applicant's property.

The applicant's activities in landscaping and replanting dune grasses on the sand dunes of the remaining portion of the site and the development of nature trails should ultimately more than compensate for the loss of any wildlife habitat because of the land committed to the facility. Since the site was a former quarry, the change to a power plant site may have resulted in less damage to the terrestrial ecosystem of this area than, for example, if the quarry had been expanded and the remaining sand dunes removed during quarrying.

The amount of land used for transmission line corridors to connect the Plant's switchyard to the applicant's power system involved the clearance of 5 acres to the nearest interconnection and another 2,250 acres for the Palisades-Argenta connection. However, since most of the land in the corridors is being leased for agricultural use, no major changes in land use have resulted. Construction of mechanical draft cooling towers as proposed by the applicant will involve the use of about 100,000 square feet (2.3 acres) of land in between the sand dunes.

The construction of the 3,300-foot intake structure and the discharge structure on the shoreline of the lake has disturbed the Lake Michigan sandy beach and bottom to a limited extent. The resultant impact on aquatic communities has been minimal since this area is a relatively sterile zone in which benthic populations are low due to the shifting sand bottom.

The cooling towers may have an adverse aesthetic impact to some observers. However, the rest of the Plant's buildings are of modern design and their style is such that the building profiles tend to blend in with the surrounding landscape. The switchyard is in a valley of sand dunes and hidden from view.

The Plant will release radioactivity into the environment during normal operation; the concentrations will be below the limits set in the Commission's regulations. Upgrading of the liquid radwaste system by the modifications described in Chapter III will be completed by spring 1973; this will reduce the radioactivity released by the Plant. Improvements in the gaseous radwaste system also would reduce the radioactive gaseous releases to as low as practicable. Neither the present nor the modified radwaste systems will release sufficient radioactivity to have a significant adverse environmental effect. In-plant radiation monitoring and controls, as well as the radiological monitoring of samples taken within and without the site boundaries, are designed to assure that all radioactive releases will be well within the Commission's regulations (10 CFR 20 and 10 CFR 50).

Transportation to and from the Plant of non-irradiated and irradiated fuel and solid radioactive wastes which are packaged and shipped in Federally-approved containers and shielded casks will be subject to both the Commission's regulations in 10 CFR 70 and 71 and the Department of Transportation's (DOT) regulations in 49 CFR 170-179. The probability of accidental release of any radioactivity during transport is sufficiently small, considering the form of the transported material and its packaging, that the likelihood of significant radiation exposure is remote. With use of proper packages and containers, continued surveillance and testing of packages, and conservative design of packages, the environmental risk is small.

Water use amounts to removal and return of 405,000 gpm of Lake Michigan water from the once-through condenser cooling system or 0.017% of the water volume of Lake Michigan during an entire year. No consumptive use of the lake water at the Plant will result from once-through cooling. However, dispersion of the thermal plume on the surface of Lake Michigan will result in water evaporation such that about 50 to 75% of the waste heat discharged in the cooling water is dissipated from the lake surface through evaporation. Thermal and chemical discharges, mechanical effects, and entrainment and impingement of aquatic biota on the Plant's traveling screens and trash racks may have some localized adverse effects in the outfall area. The location of the intake structure and the low intake water velocity, 0.5 to 0.6 feet per second (fps), through the crib structure will help to prevent any large fish from being sucked into the intake pipe. Any small fish and aquatic biota that may get through the crib structure and be drawn inside the intake pipe (where the water velocity is 9 fps) will be unable to escape damage or death from impingement on the traveling screens and trash racks. The magnitude of the anticipated loss is difficult to predict because damage and death will depend upon the migratory pattern of different fish and the population density at the intake crib location. However, the location of the intake crib and the low intake velocity have been chosen to minimize the loss.

Elevated temperatures in the mixing zone will be limited to an area of not more than about 900 acres out of a total area of 14,300,000 acres or 0.0063% of the Lake Michigan surface. Free-swimming and floating organisms are not expected to remain in the mixing zones for a sufficiently long time to be adversely affected. The dominant effect will probably be the attraction of fish to the warm water area, especially during the winter months. The migration of anadromous fish will not be blocked.

About 30% of any zooplankton, that will be entrained in the cooling water and 100% in the service water flow will be lost. Any loss, however, will serve as a food base for other biota in the lake and, since the zooplankton can recover and reproduce, any loss will have a negligible effect on the productivity of the lake.

In the once-through system, any residual chlorine discharged during the process of cleaning the condenser tubes will have toxic effects on many different organisms, particularly fish, invertebrates and planktonic materials. The adverse effect will be significant for the aquatic life adjacent to the Plant site. Limiting the chlorination to one hour per month for each condenser water box as well as limiting the concentration to 0.5 ppm of residual chlorine present in the circulating cooling water, will reduce this impact.

These adverse effects are confined to a relatively small area of the total area of Lake Michigan and are not expected to be detrimental to the overall well-being of aquatic life in Lake Michigan nor to that along the eastern shore of the lake.

In summary, the only significant adverse effects which will result from operation of the Palisades Plant with once-through cooling are those which affect the ecological communities. These are, in decreasing order of severity:

1) toxic effect of intermittently added chlorine on aquatic life in Lake Michigan near the Plant, particularly on phytoplankton and juvenile fishes, where these biota encounter water plumes containing free chlorine or chloramines;

2) interruption of the passage of juvenile fish along the shoreline corridor by the thermal plume continuously discharged from the Plant. The principal impact is the thermal shock to young fish as they are swept into the plume;

3) destruction of some zooplankton and fish from the mechanical damage they will sustain when they are drawn into the water intake system.

While there are other effects, they are considered not to constitute a significant change in the ecological system as presently constituted or an impediment to that attainable in the near future.

Operation of the Palisades Plant with the proposed mechanical draft cooling towers with no subsequent treatment of the blowdown will have a significant adverse effect on aquatic biota of the lake and on terrestrial biota on the sand dunes. The effects of thermal discharges, however, will be reduced considerably because the discharge temperature is reduced from 25F° above ambient (for the once-through operation) to < 5F° above ambient for the cooling tower operation).* If the thermal discharge were as high as 5F° above ambient, the area of the 1F° excess isotherm will be reduced from about 900 acres to about 25 acres in changing from once-through cooling to cooling tower operation. On the other hand, the biocides and corrosion inhibitors that will be present in the continuous blowdown discharge from the cooling towers are toxic to aquatic life even at very low concentrations. The accumulation of these chemicals in the lake over the decades during which the cooling towers will operate, can have a long-term adverse impact on the water quality of the lake.

The significant adverse effects of the proposed closed-cycle cooling system operating so as to discharge (continuously) untreated blowdown water to Lake Michigan are, in decreasing order of severity of impact to ecological systems:

1) enrichment of the lake water near the Palisades site by phosphates with a consequent increase in nuisance planktonic algae and a significant increase of the total quantity of phosphates in the southern basin of Lake Michigan;

2) changes in the water and chemical balance of the dunes near the proposed cooling towers with consequent change in vegetation composition or buildup of toxic chemicals;

3) zinc toxicity to fish, particularly juveniles in the nearshore area.

* The thermal discharges at the outfall with the cooling towers in operation is expected to be less than 1F° above ambient.

As in the evaluation of the once-through cooling regime, other potential effects were noted, and their impact was judged to be insignificant.

The ranking of environmental impacts of the two systems in decreasing order of severity is judged to be as follows:

1) phosphate enrichment (from cooling tower blowdown),

2) chlorine toxicity (once-through cooling regime),

3) shoreline interruption (once-through cooling regime),

4) water and chemical additions to dunes (from cooling tower drift),

5) zinc toxicity to juvenile fish (from cooling tower blowdown).

There are alternatives to most of the operations that cause these adverse impacts. For example, both phosphate and zinc can be replaced in cooling towers by chromate compounds (which, however, also produce marked impacts on ecological systems), or all cooling tower chemicals could be prevented from entering the lake by treatment of blowdown. In addition, an alternative (mechanical) method for cleaning the condenser tubes can be adopted, so as to obviate the discharge of chlorinated water to the lake, during the period when once-through cooling is employed. Finally, if necessary, the water discharge outfall could be relocated during once-through operations to avoid interruption of shoreline fish migrations. These alternatives and their relative merits are discussed further in Chapter XI.

Thus while adverse effects of operation of the once-through cooling system or cooling towers are limited, action to reduce the resultant impacts to insignificance would require the expenditure of considerable time, effort and money.

VIII. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

In attempting to determine if the existence and operation of the Palisades Plant will constitute the best long-term use of the resources that now exist in this area of Michigan, it must be realized that there are divergent opinions relating to the use and preservation of this and other shorelines. Acceptance of the philosophy that the demand for electrical power is dominant has already led the applicant to construct the Palisades Plant, despite the belief of some groups who say ideally all the shoreline should be reserved for recreational use. This concept has been stated specifically in that "no objectionable structures or development would be permitted along the wet beach and dry beach; the natural geological erosion would be permitted to continue unchallenged, and the beach would remain a stimulating tourist attraction indefinitely."[1]

The Warren Dunes Shoreline Type, of which the Palisades site is a part, stretches for approximately 8 miles along the coast of Van Buren County, and, although logging has occurred years ago, it has remained mostly a wilderness area. Similar areas have already been preserved (e.g., Warren Dunes State Park in Berrien County). The State of Michigan has undertaken to advertise this and other shore areas for recreational and secluded resort purposes and to develop all landscape assets as a base for a tourist industry and for the satisfaction of Michigan citizens. At present only 0.3% of the county's total land use (Van Buren State Park and Covert Township Park) is devoted to public recreation and Van Buren County ranks 73rd among Michigan's 83 counties in this respect.[2] Rapid completion of some planned projects, such as the construction of permanent campsites in Van Buren State Park, has been delayed by lack of finances. The completely developed facilities might tend to degrade the quality of recreation by overcrowding. Use of the lakefront areas can be expected to increase as the population density of the surrounding region increases and because of the accessibility of the areas from two major highways.

The existence of a nuclear power plant will tend to attract some tourists' attention; the applicant has recognized this by building a visitors' center on the site. Educational benefits have already been gained by the exhibits and displays as well as lectures on the subject of energy needs and principles of atomic power presented to young and adult groups by the applicant since the center was built. There are also plans to develop nature trails through the dunes on the site that may be used by visitors to the parks. Since there are no other plans to restrict the use of the beachfront within the applicant's boundaries except at the discharge canal location (with possible rare exceptions in emergencies), the use of the beach in conjunction with the neighboring parks will not be seriously affected. Similarly, use of the lake will not be curtailed to a significant degree by the cooling water effluent from the Plant. In fact, it is a distinct possibility that any increase in the temperature of the lake water close to the beach will be beneficial to both swimmers and fishermen.

The long-term effect of the chemical effluents that will be discharged from the Plant cannot be forecast with exactness. Some chemicals, such as phosphates, even in modest amounts tend to promote long-term productivity, and with continually increasing concentration, such chemicals will partially cause eutrophication of Lake Michigan. Thus they are considered harmful to the future of the lake. Similarly, some other chemicals are detrimental to either the short-term or long-term use of inshore water for fish in the spawning and juvenile stages. The Plant will probably not discharge total amounts of chlorine or phosphate greater than from the sewage system of South Haven. However, further use of Lake Michigan as a dumping place for chemical wastes can be minimized by alternatives that have been outlined above and in Chapter XI by limiting the concentration, frequency, and length of time of the chemical treatment during Plant operation. In Chapter V, Figure V-1 shows the changing chemical characteristics of Lake Michigan over a 100-year period. Proper restrictions on chemical discharges during the next 100 years are necessary to preserve and maintain Lake Michigan as a valuable natural resource of the United States.

There is popular sentiment to maintain the dune area around much of the Great Lakes in a nearly natural state as a unique scientific and educational asset for the study of ecosystems and natural history. Any incursion that alters either the covering vegetation and important wildlife area or the dunes themselves reduces the value of this limited area for this long-range purpose. Wave erosion is slowly decreasing the total area available. Traffic in the area has increased with the development of beach-front lots for resort cottages and has been accelerated by the influx of tourists, and more recently by the existence of the Plant. Although exact predictions cannot be made at present, the dune area immediately around the proposed cooling towers may be altered considerably by the large quantities of water and dissolved solids that will be ejected with drift and evaporatives losses. Additional disturbances and removal of sand from these dunes will be required during construction of the cooling towers; however, the current effort of the applicant to maintain a cover of vegetation and to minimize wind erosion should continue without pause.

Utilization of the 487 acres of land within the applicant's boundaries for a power plant should have no impact on the growth of industry, agriculture, or population in Covert Township or in Van Buren County. The Department of Agriculture in Appendix XII-2 states that the project does not involve any prime agricultural land so it doesn't directly affect the crop production base of the county. This land has been used only as a sand quarry and does not appear to have other potentials that would be of equal or greater value to the local economy than will the increase in tax base that will result from operation of the Palisades Plant. The State Equalized Valuation of the Palisades Plant at present represents 46.1% of the industrialized valuation or 12% of the total valuation of Van Buren County.[3] If increased availability of electricity or other factors were to stimulate more rapid economic growth in Van Buren County, the unavailability of the land included in the Palisades site would not be a retarding factor.

In the last several years, a great deal of public interest has developed regarding the damage to the water quality of Lake Michigan, mainly from discharges from industrial plants, power plants, and municipal treatment plants. About 10 nuclear power plants have been constructed at 7 sites or are under construction on the shores of Lake Michigan. Palisades Plant is one of the smaller units to be built on the lake. Although this Statement deals with an evaluation of the potential incremental effects of the Palisades Plant on the environment, the Commission is supporting a study at Argonne National Laboratory on the long-term effects of all nuclear power plants on Lake Michigan.[4] The Great Lakes Research Program at Argonne is also being conducted with the cooperation of the University of Michigan and the Great Lakes Institute at the University of Wisconsin - Milwaukee. Table VIII-1 lists the nuclear power plants built, under construction, and proposed for location on Lake Michigan.

The Commission is also supporting a study "Year 2000"[5] to investigate the long-term radiological effects of discharge of radioactive effluents from all nuclear power plants, including the Palisades Plant. Palisades Plant is expected to have a 40-year lifetime and thus will be probably operating during the first decade of the next century. This study, initiated in 1970, involves estimating potential radiation doses and dose commitments to individuals and population groups as a result of selected release rates from reactor and other nuclear facilities in a large geographic region. Thus, the incremental dose contribution of one nuclear power plant, such as Palisades, is of importance as the number of nuclear power plants increases during the coming years.

TABLE VIII-1

NUCLEAR POWER PLANTS BUILT OR UNDER CONSTRUCTION ON LAKE MICHIGAN

	Capacity MWe	Expected Completion Date
Big Rock Point	70	1963
Kewaunee	530	1972
Point Beach Unit 1	450	1971
Point Beach Unit 2	450	1972
Zion Unit 1	1100	1972
Zion Unit 2	1100	1972
Cook Unit 1	1100	1972
Cook Unit 2	1100	1973
Palisades	700	1971
Bailly	685	1976

In conclusion, it is considered that the major adverse impact of the existence and operation of the Plant will be ecological (limited in extent within the dune area, and mild, but long-lasting, in Lake Michigan). The use of the site for a power Plant will be beneficial in serving both the economic and electrical needs of the county and State. Alternatives to this choice are now limited. Options that remain are outlined in Chapter XI.

REFERENCES FOR CHAPTER VIII

1. "Shoretype Classification of Van Buren County, Michigan," Shoretype Bulletin No. W, Department of Resource Development, Agricultural Experiment Station, Michigan State University, East Lansing, Michigan (1958).

2. Van Buren County Comprehensive Plan for Sewer and Water Facilities Memorandum No. 3, "Growth Potentials, Agricultural Production, Land Patterns, and Trends." Prepared by Vilican Lemon and Associates, Inc., Southfield, Michigan, July 1971.

3. Van Buren County Comprehensive Plan for Sewer and Water Facilities Memorandum No. 2, "Economic Analysis." Prepared by Vilican Lemon and Associates, Inc., Southfield, Michigan, March 1971.

4. Rowland, R. E., and Gustafson, P. F., Radiological Physics Division: Annual Report - Environmental Studies, July 1969 through December 1970, Argonne National Laboratory, Argonne, Illinois, ANL-7760 (Part III).

5. Strauch, S., "Year 2000 - Nuclear Power and Man," Presented at the Third National Symposium on Radioecology, Oak Ridge, Tennessee, May 10-12, 1971.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The Palisades Plant has already been constructed and will have a nominal life of 40 years. Because of the increasing demand for electricity, it might be more realistic to consider this land as committed for an indefinite length of time to power plant use. During (and partly before) construction of the Plant, a limited portion of the geographically important Warren Sand Dunes Shoreline Type was irreversibly altered by excavation. Another part of the dunes will be excavated to prepare sites for the proposed two cooling towers if the alternative to build cooling towers is exercised. The precedent for alteration of the dunes was set long ago through the construction of roads to the beaches and resort cottages. Although there is considerable scientific and educational interest in these and other dunes, most of the site land was privately owned; the county and State have control of only the two parks near the site. Further degradation of the dunes can be minimized by advanced planning of public use.

Both land and water resources could suffer cumulative detrimental effects as a result of the small concentrations of chlorine, zinc, phosphate, chromate and other chemicals in alternative biocides that will be discharged from the Plant. The adverse impact on the inshore area of the lake, especially in the vicinity of the discharge canal, may not be irreversible.

During the production of electricity in a nuclear plant the fissile component (uranium-235) of the uranium fuel is irretrievably consumed. If the Plant is operated continuously for 40 years, the consumption of uranium (2.74% enriched) would be approximately 1,300 metric tons (1,430 U.S. tons) based on the production of 24,000 MWt-days per metric ton of uranium. Most of the nonfissile component of the fuel will be recoverable.

During the fissioning process, some of the uranium-238 present in the nuclear fuel is converted to a fissile material, plutonium-239. This fissionable material can be used as a nuclear fuel in the future fast breeder reactor systems. Thus, the byproduct of the light-water thermal power reactors, plutonium-239, has a potential future as the nuclear fuel for the liquid metal (sodium-cooled) fast breeder reactors (LMFBRs).

At the end of the expected life of this reactor the site could be reclaimed for other purposes if desirable. At that time some of the structural components will have become highly radioactive through neutron activation and also will be contaminated; thus such materials will not be salvagable. The storage of these components as well as other solid radioactive waste from this Plant will require permanent

X. NEED FOR POWER

The applicant, owner-operator of the Palisades Plant, is a principal member, along with Detroit Edison Company, of the Michigan Power Pool and the two are participants in the East Central Area Reliability Coordination Agreement (ECAR). These utilities, by joint planning and cooperative use of their combined generating capacity and transmission facilities, meet the electrical power demand of Michigan's lower peninsula. The Pool is designated by the Federal Power Commission (FPC) as Power Supply Area No. 11 (PSA-11) and is part of the East Central Region (Region III) of the FPC National Power Survey.[1]

In 1965, when the applicant initiated planning for the Palisades Plant, the peak demand in PSA-11 was 7,145 MWe. With the FPC's estimated annual growth rate of 6% for the Michigan Pool, the peak load was projected to be 9,600 MWe for 1970. However, the observed peak demand of approximately 9,000 MWe was about 6% below the projected demand, primarily due to an unusually low rate of growth from 1969 to 1970.[1]

Analysis of the peak demand on the applicant's system for the years 1960 to 1970[2] shows a variable annual growth in demand between 2% and 12%, with a compounded annual growth of 6.2%. A similar growth pattern is observed in the records of the Detroit Edison Company.[3] This pattern of up-and-down annual growth rate supports the conclusion that conditions leading to a high growth-rate period are likely to exist during several years following a low growth-rate period. Consequently, the applicant's projection of growth rate in power demand of somewhat more than 7% per year during the next 5 years is reasonable to use in assessing the need for the Palisades Plant. The applicant's projection of peak demands[4] is shown in Table X-1 for the years 1972 through 1975. Actual experienced maximum load values during the decade 1960 to 1971 are also shown in the table. Table X-1 also shows the winter and summer peak loads. The applicant's system is considered to be a winter peaking system with a 7.4% increase in the winter peak load for winter 1972. A 6.6% increase of summer peak load is expected for summer 1972.

In planning generating capacity to meet the projected peak loads, the utilities have to determine the necessary reserve capacity to compensate for planned outages for maintenance and emergency outages due to equipment failure. Other factors affecting this

TABLE X-1

Peak Power Demands in Applicant's
System During 1960 to 1975

[Except as indicated by footnotes, the data are taken from Applicant's "Electrical Forecast Book" included as Exhibit 1 of Reference 4.]

Year	Summer Load MWe Demand	Summer Load % Inc	Winter Load[a] MWe Demand	Winter Load[a] % Inc	Annual Load Factor Percent	Ratio of Summer Peak To Winter Peak
1960	1,749.9	4.2	1,876.4	1.9	61.7	93.3
1961	1,833.3	4.8	1,963.4	4.6	61.3	93.4
1962	1.932.8	5.4	2,065.6	5.2	64.1	93.6
1963	2,010.1	4.0	2,217.4	7.3	63.2	90.6
1964	2,171.7	8.0	2,374.9	7.1	63.1	92.4
1965	2,377.1	9.5	2,570.0	8.2	64.6	92.5
1966	2,521.8	6.1	2,860.4	11.3	63.4	88.2
1967	2,672.8	6.0	2,970.0[b]	3.8	64.7	90.0
1968	3,000.0[b]	12.2	3,179.7	7.1	64.8	94.3
1969	3,183.9	6.1	3,377.9	6.2	65.7	94.3
1970	3,343.2	5.0	3,457.9	2.4	66.6	96.7
1971	3,603.8	7.8	3,711[c]	7.3	66.0	97.1
1972*	3,840.0	6.6	4,040.0	7.4	66.5	95.0
1973*	4,120.0	7.3	4,340.0	7.4	66.4	94.9
1974*	4,440.0	7.8	4,660.0	7.4	66.5	95.3
1975*	4,740.0	6.8	4,970.0	6.7	66.7	95.4

* Projected

[a] Winter load peak following summer load peak. The winter load peak may occur in following calendar year.

[b] Peak adjusted to reflect estimated maximum demand without voltage reduction. Actual recorded peaks were: 1967 Winter Peak - 2,941 MWe and 1968 Summer Peak - 2,979 MWe.

[c] The applicant reports in a letter dated March 7, 1972 (Reference 5) this "maximum system load to date" occurred on January 25, 1972. This was slightly less than the applicant's projected value (3,760 MWe) given in the Forecast Book.

determination are the generating unit size, uncertainty of load forecasts, forced outage performance of both new units and older units, slippage of inservice dates of units under construction, and interconnections with other systems. In view of the consequences to the public of insufficient capacity to meet the peak loads, the utilities' judgments of these factors have tended to be conservative; i.e., to project a larger reserve capacity. The judgments of most utilities in the East Central Region have resulted in planned reserve capacity margins of approximately 20% of peak load.[1]

The Michigan Power Pool now requires a capacity reserve of 17%,[6] a criterion which the FPC has recently pointed out, "may be too low".[6] The applicant's installed capacity on May 1, 1971, was 3,897 MWe.[4] Since then, Palisades has been put into service at 60% of full power (420 MWe), and the Saginaw Plant (82 MWe) has been retired. Application of the 17% criterion means that the applicant will have to add about 1,050 MWe capacity by mid-1974 in order to meet the projected peak demand in winter 1974-75.*

Both the applicant and Detroit Edison plan to add generating capacity as shown in Table X-2. The added capacity is intended not only to provide for the increased demand but also to permit the Pool to retire obsolete facilities. Some of the capacity of the pumped storage facility is obligated to a utility outside of the Power Pool.[2] The additions shown in Table X-2 were regarded as necessary and were based on a 6% annual compound growth curve from 1965; they will provide a reserve capacity slightly in excess of the 17% criterion if they become operable on schedule.

The reserve margins for the Michigan Power Pool were analyzed in a FPC staff report in October 1971.[6] The projected summer 1972 situation was updated by the FPC staff[7] in March 1972. Table X-3 shows the forecasted power supply situation for summer 1972 and winter 1972-1973. The tabulation has been prepared by the staff using data as referenced in the footnotes.

As the tabulation indicates, operation of the Palisades Plant at 60% (420 MWe) provides the applicant with an estimated reserve of 11.1% for the summer of 1972 which is backed up by estimated 19.5% reserve

* The additional 280 MWe from full-power operation of Palisades will reduce from 1,050 MWE to 770 MWe. However, retirement of obsoleted facilities in the applicant's system during the period between now and winter 1974-75 will increase the requirements for additional capacity. (It should be noted that the applicant's Midland Plant Units 1 and 2 are not expected to be on-line until after winter 1974-75.)

TABLE X-2

Additions to Generating Capacity of the Michigan Power Pool
from 1971 through 1974

Plant Name	Owner	Fuel	Date on Line	Plant Capacity (MWe)
Monroe Station Unit No. 1	Detroit Edison	Coal	April 1971	800
Palisades Unit No. 1	Consumers Power	Nuclear[a]	1971	700
Monroe Station Unit No. 2	Detroit Edison	Coal	1972[c]	800
Unit No. 3	Detroit Edison	Coal	1972/1973	800
Unit No. 4	Detroit Edison	Coal	1973	800
Ludington Pumped Storage	(combined)	Hydro	1973	1872[b]
Dan K. Karn Addition	Consumers Power	Oil	1974	660

[a] Pressurized-water reactor (PWR).

[b] Detroit Edison, 917 MWe; Consumers Power Company, 955 MWe.

[c] Present schedule is May 1972 (Reference 4).

TABLE X-3

Projected Demands and Reserve Margins for Consumers Power, Detroit Edison, and the Michigan Power Pool During Summer 1972 and Winter 1972-73

	Consumers Power	Detroit Edison	Michigan Pool
Summer 1972[a]			
Installed capacity (MWe)	4,155[b]	7,632[c]	11,787
Estimated demand (MWe)	3,740[d]	6,385[d]	10,125
Reserve margin (MWe and percent of estimated demand):			
With Palisades at 60%	415(11.1%)	1,247(19.5%)	1,662(16.4%)
With Palisades at 100%	695(18.3%)	1,247(19.5%)	1,942(19.2%)
Needed reserve margin[e]	636(17%)	1,085(17%)	1,721(17%)
Winter 1972-73[f]			
Installed capacity (MWe)	4,213[g]	7,716[h]	11,929
Estimated demand (MWe)	3,881[i]	6,065[i]	9,946
Reserve margin (MWe and percent of estimated demand):			
With Palisades at 60%	332(8.6%)	1,651(27.2%)	1,983(19.9%)
With Palisades at 100%	612(15.8%)	1,651(27.2%)	2,263(22.7%)
Needed reserve margin[e]	660(17%)	1,031(17%)	1,691(17%)

[a] Basic data from Reference 7

[b] Summer rating of existing units, including Palisades Plant at 60% of rated power, after retirement of Saginaw River Plant.

[c] Summer rating of existing units, plus Monroe Unit No. 2 (789 MWe).

[d] System load less 200 MWe capacity, equally divided between participants, as firm receipts from Ontario Hydro, scheduled for May 29 to September 17, 1972 period.

[e] System criterion is 17% (see Reference 6).

[f] Preliminary estimate including winter ratings.

[g] Includes Palisades at 60% (420 MWe); Kalamazoo Steam Plant (24 MWe) assumed retired (see Reference 4).

[h] Assumes 166 MWe retired in October 1972.

[i] Includes 200 MWe capacity obligation, equally divided between Pool partners, to Ontario Hydro.

in the Detroit Edison system. Since the reserve margin is 415 MWe, the applicant will be unable to meet the demand if the Palisades Plant is not operating. (It should be noted that the applicant's projected reserve is still 221 MWe less than that required by the 17% criterion.) The Power Pool reserve generation capability could become critical if Monroe Unit 2 of Detroit Edison were not in operation for the summer 1972 peak load. The Michigan Power Pool reserve margin would then be about 8.6%. In this case, the availability of the Palisades Plant at rated capacity (700 MWe) for the duration of the critical period would increase the Pool reserve to about 11.4%.

The tabulation shows that, for the next winter peak load, the applicant's estimated reserve of 8.6% (Palisades Plant at 60% of rated capacity) is well below the acceptable level. However, the Pool reserve of almost 20% should be sufficient to meet emergency situations in lower Michigan in case the Palisades Plant is not operated at more than 60% of rated capacity.

Operating with a low reserve margin can adversely affect equipment reliability by making it difficult, or even impossible, to accomplish necessary scheduled maintenance. The applicant has noted[5] that the forced outage rate increased to 11.9% (percent of installed capacity out of service due to forced outage on an average weekday) in 1970, with the 1971 rate expected to be similarly high. The high forced outage rate created critical situations. The applicant cites two specific events. On January 25, 1972, between 6 and 7 p.m., the applicant had to import 766 MWe in order to meet a 3,711 MWe demand; at the time, 715 MWe of the applicant's capacity had been forced out of service while 84 MWe of the capacity was out for scheduled maintenance. On March 1, 1972, between 6 and 7 p.m., the applicant had to import 1,350 MWe to meet a 3,480 MWe demand; at the time, 960 MWe was forced outage and 397 MWe scheduled outage. While it is incorrect to attribute all increases in the forced outage rate to the constraints of operating with a low reserve margin, it is clear that operability with a low reserve margin tends to increase the forced outage rate.

As noted earlier, the applicant's projections (Table X-1) are based on an average of about 7% growth in peak demand each year. It is important to recognize that even this rate may be exceeded. Culberson[8] has recently tabulated the total energy consumed in the United States since 1956. Calculations based on his figures indicate that the national growth rate in recent years has been about 8% per year. A similar rate of growth of peak load would require that the planned new generating facilities (Table X-2) be completed on schedule to assure an adequate reserve capacity at all times. A decrease of the annual growth rate cannot be expected during the next decade. The southeastern area of Michigan (Metropolitan Detroit), which uses about 60% of the power generated in PSA-11, could show a leveling off in power demand due to an industrial and population saturation factor. However, the southcentral and southwestern sections of the State have the potential, in terms of availability of property for industrial development and population growth centers, of showing increased economic growth and electrical power consumption. Thus, any decrease in the annual growth rate of the power demand will likely be minimal, unless active measures are taken to control energy demand growth rates.

The applicant and Detroit Edison Company, in their joint planning efforts, have provided for orderly growth of the generating capacity of the Michigan Power Pool to meet the anticipated power demand. The generating capacity is needed at this time to meet the present power needs of the area in 1972 and to avoid a potential critical power shortage in the near future.

In addition to the applicant's participation in the Michigan Power Pool, the applicant is a member of ECAR, a regional electric power reliability council, which coordinates planning and operation in the area of lower Michigan, all of Indiana and Ohio, most of Kentucky and West Virginia, and parts of Pennsylvania, Maryland, Virginia, and a small area of Tennessee. As a participant in ECAR, the applicant benefits through coordination and long-range planning of the council. However, it should be emphasized that ECAR is <u>not</u> a power pool. Even though power to meet an unforeseen emergency may be made available through an interconnection, the applicant cannot depend on it. In reviewing the applicant's situation, the staff of the FPC Bureau of Power states[7] that "the power supply situations for the 1972 summer in other regional council areas adjoining ECAR are such that potential deficiencies in desired levels of reserve margin adequacy also loom within those areas" and concludes that "it does not appear that firm power from the adjoining areas is available to the Consumers Power Company." In other words, the applicant has to depend for firm contract power on its Pool partner and on purchases from Ontario Hydro.

With respect to the situation in ECAR, the FPC cautions[9] that the 18% regional reserve expected during the summer 1972 depends on more

REFERENCES FOR CHAPTER X

1. Federal Power Commission National Power Survey: Electrical Power in the East Central Region, 1970-1980-1990, A Report to the Federal Power Commission, prepared by the East Central Regional Advisory Committee, December 1969.

2. Consumers Power Company Annual Report, 1970, Jackson, Michigan.

3. Detroit Edison Company Annual Report, 1970, Detroit, Michigan.

4. Testimony by W. Jack Mosley, Vice President of Consumers Power Company (Palisades Plant - Docket No. 50-255) in Hearings before the Atomic Safety and Licensing Board, Kalamazoo, Michigan, September 27, 1971.

5. Letter from A. H. Aymond, Chairman of the Board, Consumers Power Company to F. T. Hobbs, Assistant Secretary, U. S. Atomic Energy Commission, dated March 7, 1972.

6. Letter from J. H. Nassikas, Chairman of the Federal Power Commission, to C. L. Henderson, Assistant Director of Regulation for Administration, U. S. Atomic Energy Commission, dated October 22, 1971 with Staff Report of Bureau of Power of the Federal Power Commission on Palisades Plant.

7. Letter from T. A. Phillips, Chief, Bureau of Power Federal Power Commission to W. B. McCool, Secretary, U. S. Atomic Energy Commission dated March 8, 1972.

8. Oran L. Culberson, "The Consumption of Electricity in the United States," ORNL-NSF-EP-5, Oak Ridge National Laboratory, Oak Ridge, Tennessee, June 1971.

9. Letter from T. A. Phillips, Chief, Bureau of Power, Federal Power Commission, to Lester Rogers, Director, Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission, dated March 22, 1972.

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

A. SUMMARY OF ALTERNATIVES

The present and future demand for electrical energy in the lower peninsula of Michigan was discussed in Chapter X. The generating capacity now available to the applicant to meet its commitment to the Michigan Power Pool is inadequate without operation of the Palisades Plant. Although the applicant and its partner in the Pool, Detroit Edison Company, have been able to arrange for the purchase of some firm power from adjacent utility systems, such as the Hydro-Electric Power Company of Ontario, for 1972, there is an increasing probability for the next year or two that sufficient power will not be available through the interties to satisfy the needs of the Power Pool if forced outages of a major generating unit occurred during the period of peak load. In this case, the Michigan Power Pool would be forced to curtail energy to some part of their load or reduce voltage throughout their system. Operation of the Palisades Plant will lessen this probability.

Permanent curtailment of the operation of the Plant would result in the irretrievable loss of most of the resources committed to the construction of the Plant without removing impacts already created by construction. In addition, a large part of the capital investment at the Palisades site would be unrecoverable and probably borne by the investor and by the customer in higher rates. A replacement plant would cost much more than an abandoned facility[1] and would create additional environmental impacts at the same or other site.

In choosing the site for the Palisades Plant, the applicant made an economic analysis which included the following types of alternatives: location of site with respect to load; type of fuel and cost; transportation, primarily of bulk fuel; method of waste heat dissipation; and other quantifiable variables of lesser financial significance. The applicant selected the Palisades site and a nuclear-fueled, steam-turbine generating unit with once-through cooling of the condenser using Lake Michigan as the source of the water coolant. In consideration of other available locations, offshore sites were not considered as an alternative during the original site selection in 1965, since the technology for offshore nuclear power plants did not exist. A number of studies on this subject have been made[29,30] but time would not permit construction of an offshore plant as an alternative to the Palisades Plant in meeting the peak load requirements for 1972. The selection of the site involved relatively minimal impact on the environment from the transmission line additions to the existing bulk power system necessary to integrate the Palisades Plant into the existing power system for the applicant's customers.

1. <u>Alternative Fuels and Sources</u>

There are four alternatives to the use of nuclear fuel in Michigan. They are natural gas, oil, coal, and no further expansion of the power generating capacity. The Federal Power Commission (FPC)[2] reported that natural gas and oil fuels combined contribute to the generation of only 0.2% of the electrical energy consumed in the East Central Region and forecasts that, although consumption of these fuels will increase in the future, the fraction of the electric energy produced using these fuels will not increase. The reason for this forecast is that neither natural gas nor oil is presently in abundant supply from local sources within the region. Over 70% of the natural gas produced in the United States in 1968 came from sources in Louisiana and Texas, while the industries of the States of Louisiana, Texas, Arkansas, and Oklahoma accounted for the consumption of about one-third of the total nation-wide production.[3] There are gas wells in Michigan which do supply fuel for numerous, small, gas-turbine generating units used for peaking purposes in local situations. These units provide for flexibility of operation and dispersion of environmental impacts, but do not contribute to the base-load capability of the system, due to the limitations of natural gas supply and storage facilities. However, natural gas is not a reasonable economic choice for large power plants that must depend on interstate delivery of the gas by long pipelines from the principal continental sources.

Fuel oil is not presently an economically competitive fuel in Michigan, due to the long distance from the principal sources, which are: the southcentral States of Texas, Louisiana, and Oklahoma; central Canada; Venezuela; northern Africa; and the Arabian peninsula. Since the domestic consumption of oil far exceeds the combined United States and Canadian production,[4] importing oil from overseas is necessary. Evaluation of the use of oil as an energy source for proposed power plants must therefore include the shipping costs associated with ocean-going tankers and, possibly more important, the reliability of delivery from foreign sources in today's troubled world.

Coal is the primary alternative fuel source and would have been the fuel type chosen by the applicant for some of the optional plant sites.[5] This is particularly true when a power plant existing at a site is committed to the use of coal, since certain auxiliary features such as coalyards, coal-handling equipment, and the extensive railroad equipment necessary for handling large quantities of coal would already be available. However, for a new site such as Palisades, coal was not a reasonable alternative. From an economic viewpoint, the cost of coal used by utilities in Michigan in 1966 was higher than in any other State in the East Central Region. This is primarily due to costs of transportation, since Michigan is farther from the coal supply than the other States. Most of the coal is obtained from the southern tier of the East Central Region, which includes eastern Kentucky, West Virginia, and southwestern Virginia.[2] In addition, the use of coal requires additional capital investment for coal-handling equipment and for pollution abatement equipment; even today the latter may prove inadequate to reduce particulate and gaseous emissions to the level required by increasingly restrictive air-quality standards.

The use of coal as a fuel at the Palisades site would have necessitated the commitment of a much larger area of land for coalyards and coal-handling equipment and for fly-ash storage. This would have led to the destruction of a sizable segment of the sand dunes at this site. The environmental impact on the land would have been more severe. The environmental impact on Lake Michigan might also have increased. In terms of the radiological impact, recent studies indicate that coal-fired plants may lead to radiation exposures to the general population at a level similar to, or greater than, exposures derived from operation of power plants using pressurized water reactors.[6] This is due to the presence in the emissions of a coal-fired plant of the radioactive daughter products of uranium and thorium, which occur naturally in coal. The environmental impact due to radiological considerations may therefore be as great for a coal-fired power plant as for a nuclear plant, or greater, depending on the concentrations of radioactive elements in the coal and on the gaseous effluent control built into the coal-fired plant.

Based on comparative costs of nuclear fuel and coal as discussed in the applicant's Environmental Report,[5] operation of the Palisades Plant should be financially preferred over the older coal-fired plants. The Palisades Plant will result in lesser adverse impact than older coal-fired plants, which need to be retired or to be used to a lesser extent because of high maintenance costs, low efficiency and poor reliability. These latter facilties, which were constructed prior to availability of adequate smoke abatement equipment, produce and discharge to the environment considerable quantities of fly ash, sulfur and nitrogen oxides, and other hazardous materials.[6,7] Although backfitting of these existing coal-fired power plants with modern pollution control equipment can be done,[5] it is not expected that the gaseous effluent of these plants will be as clean as that of the nuclear Plant.

Hydroelectric power from natural sites is not a practical alternative, since the remaining available sites in Michigan, as in all of the East Central Region, would provide only small incremental increases in generating capability.[2] Pumped-storage hydroelectric generation facilities can be built in a way that natural waters are not unduly disturbed. However, this type of facility requires an off-peak capacity for the pumping phase which was not available when the Palisades Plant was undertaken. The applicant has an 1,800-MWe pumped-storage generation facility under construction (completion date of 1973) which will use the off-peak capacity that will be available when Palisades becomes operational.

Analysis by the FPC[2] indicates that importing power from the surrounding regions would not be a reasonable alternative to adding generating facilities in the Michigan Power Pool. The reserve margins of many of the utilities in the East Central Area are below the level desired for dependability, and most of these utilities are having difficulty in constructing generating capacity fast enough to maintain the reliability of their own systems. Therefore, it is not reasonable to place reliance on power import in lieu of construction of needed facilities. In order to maintain the desired level of reliability of a total region, it is necessary that each power pool and each utility provide its balanced share of the region's electric energy needs, provide for its customers' needs, and be ready and able to help a neighboring utility and its customers in case of a local deficiency in generation. The FPC reaffirmed these remarks in its comments in Appendix XII-6 in which delays in getting both nuclear and fossil-fueled plants on line in time in the ECAR and the Mid-America Interpool Network regions may result in potential critical power shortage in the mid-west for 1972.

The alternative of not supplying additional power is not considered a feasible option. The Palisades Plant was built to meet the immediate growth of peak load and to provide a reliable base-load capability for the future. The need for power from this Plant is outlined in Chapter Ẍ. The FPC in Appendix XII-6 also describes a number of fossil and nuclear power plants to come on line in 1972 to maintain the 18% regional reserve margin of ECAR. Non-emergency type of methods for reducing power demand and growth rates are not likely to be effective within the short period of time considered in the present assessment.

2. Alternative Cooling and Chemical Treatment Systems

When the original decisions were made to construct a 700-MWe power plant, the applicant selected once-through cooling of the steam condenser on the basis of the lowest capital investment and operating costs, since the optional plant sites had available the necessary quantities of cooling water. However, in view of the potential damage that could be done to the aquatic environment by discharging large volumes of heated water into Lake Michigan, the applicant agreed with the intervenors to equip the Plant with a closed-cycle cooling system using mechanically induced-draft wet cooling towers. The environmental impacts of both cooling methods have been evaluated and assessed in preceding sections of this Statement. The summary of the most significant adverse impacts due to the heat dissipation methods (see Chapter VII) indicates the need to discuss alternatives of design and/or operation of other cooling systems before the cost-benefit evaluation is performed.

a. Cooling Towers[31,32,33]

The principal impacts of the closed-cycle wet cooling tower system adopted by the applicant are due to the additions of chemicals to the lake through the blowdown, and by the addition of chemicals and water to the surrounding land as a result of the cooling-tower drift. Although the chemicals may be varied in an effort to reduce adverse impacts during future operation, it is probable that any of the chemicals suitable for corrosion inhibition and biological defense (see Appendix V-1) will have an adverse effect on the lake and possibly on the terrestrial ecosystem. The adverse impact on the lake ecology due to the release of chemicals in the blowdown can be reduced by installing a treatment system to remove the potentially toxic chemicals prior to the release of the blowdown water to the lake. Chromate and phosphate recovery systems are commercially available; the selection of a cooling tower blowdown treatment would commit the Plant operator to a particular corrosion-inhibitor. Complete elimination of the chemicals released to the terrestrial environment is impossible with the wet cooling tower, but proper design can minimize the drift[7] and reduce the impact of chemicals and excess water on the adjacent land and its ecosystem.

The adverse impacts due to chemical loss from the towers to the environment are reduced with the use of natural-draft wet cooling towers. This is due to a reduced requirement for corrosion inhibitors since much of the structure of these towers is corrosion-resistant concrete. Drift is also less with natural draft towers due to lower air velocity due to the absence of fans in the tower.[7] The capital cost of a natural-draft wet cooling tower is greater than for the mechanical-draft tower, but a lower operating cost would balance this out over the long term. Natural draft cooling towers do not derate the Plant as much as mechanical draft cooling towers but result in reduced thermal efficiency of the Plant to a greater extent than mechanical draft cooling towers. However, a natural-draft cooling tower for the Palisades Plant would be more than 400 feet tall, and could be considered by many people to have a severe aesthetic impact on the naturally scenic sand dunes. Furthermore, natural-draft cooling towers would disperse fog and drift and cause icing over a wider area beyond the Plant site area. Since a large consumptive use of water is involved in evaporation and drift, the fog formed and emitted from the higher elevation of a natural-draft cooling tower might affect the traffic on the nearby highways. The fog and ice from the mechanical draft cooling tower would affect primarily the onsite area since the plume will be emitted at about the same elevation as that of the sand dunes.

Dry cooling towers (induced- or natural-draft) eliminate the drift problem, and the blowdown impact is significantly reduced. This latter improvement results from the fact that dry cooling towers do not lose water by evaporation to the atmosphere, and hence, do not concentrate naturally-occurring chemicals in the cooling water, thus minimizing the need for blowdown. The use of this type of cooling tower offers the advantage of increased flexibility in siting thermal power plants, since a large source of cooling water would no longer be necessary. A disadvantage is that back-pressure turbines for pressures in the range of 8-inch Hg absolute, which must be used with dry cooling towers, are not manufactured in the United States. Another disadvantage is that the thermal efficiency is lower, since it is governed by the dry-bulb rather than the wet-bulb temperature of the air. These dry cooling towers require a greater heat transfer surface because of inefficiencies in heat transfer adding to the cost of installation and space requirements necessitating a structure far greater in size than the natural-draft wet tower. The infancy of the art of large dry cooling towers is obvious in estimates of capital and operating costs, which have ranged from \$20 to \$50 per kilowatt[33] capacity for a nuclear plant, and in estimates of the increased cost to the consumer, which have ranged from 2% to 10%. Details on siting, performance, and economics of dry cooling towers are described by

Smith and Larinoff,[33] who point out the advantages and disadvantages of this cooling system for dissipating heat to the atmosphere. Thus, this type of cooling tower would add more than $25-million to the Plant cost with the once-through cooling system (not including back-fitting costs).[8] In addition, no dry cooling tower has ever been operated on a power plant of greater than 250 MWe;[8] thus experience with investment costs and operation is not presently available. (Again the natural-draft type of tower would be a large structure that would have an adverse aesthetic impact.)

b. Cooling and Spray Ponds

Another closed-cycle cooling system is a cooling pond. Large man-made, relatively shallow ponds are constructed to provide a large surface area for evaporation of water, and thus heat dissipation to the atmosphere. The surface area required for cooling ponds is large (1 to 3 acres per megawatt of electricity) and it could be difficult and costly to purchase the needed land and build a pond. The present site acreage of 487 acres would be insufficient to build a cooling pond. To dissipate the waste thermal energy of the Palisades Plant, the cooling pond area would have to be more than 1,000 acres.[10,11] The use of cooling ponds at the Palisades site would require the destruction of the sand dunes, or the construction of a conduit to take the warmed water at least 1 mile to property (which could be purchased) beyond the sand dune zone. Destruction of the sand dunes would be an unacceptable environmental impact upon an important geologic feature. Removal of more than a thousand acres of land, inland of the sand dunes, would also be a loss of an important natural resource in this agriculturally productive region.

Spray ponds, though similar to cooling towers in operation, depend upon local temperature, humidity, and wind conditions, and thus their reliability is variable. The loss of land and the capital cost required for this alternative is not justified for a benefit whose reliability is questionable, particularly during the summer months, when the peak electrical load is experienced. A spray pond for use at the Palisades Plant may require about 30 acres at a design temperature rise of about 25F°. The costs of such a cooling pond could be estimated to be about $7-10 million.[36]

There are adverse environmental effects associated with a spray pond at the Palisades Plant. If the scenic sand dune area were to be used, the land would require defoliation and clearing. During winter operation, drift and spray would result in local icing. The effect of any salt content of the spray is not known, but it is likely that the local flora would be affected. Under adverse humidity conditions, local fogging can occur.

c. Once-Through Cooling

The most significant adverse effects on the local environment at the Palisades Plant site as a result of using the once-through cooling method (see Chapter VII) are, in increasing order of severity, (a) zooplankton mortality due to entrainment in the cooling system, (b) interruption of fish movement in the shallow waters along the shore, and (c) chemical (chlorine) poisoning of the aquatic environment.

The zooplankton mortality will occur with the once-through cooling system. However, at the Palisades site the loss of live organisms is small relative to the available numbers, and does not lead to much alteration in the food chain, since the rapidly regenerating algae are quickly able to restore the population to equilibrium with the need of their natural predators. Therefore, no alternative action needs to be considered to reduce this impact, unless future observations identify impacts larger than anticipated by present assessment.

Alongshore movement of fish in the shallow water beach zone is not now a significant aquatic feature for the fish species presently abundant near the Plant site. However, some fish species which are making a comeback in Lake Michigan do use the beach zone during their annual life pattern and will be prevalent near the Plant site. Therefore, alternatives of Plant design should be considered to reduce the adverse impact of the thermal discharge of the once-through cooling system. One alternative is the modification of the discharge canal to increase the exit velocity from the present 2 feet per second (fps) to 10 fps. This would significantly reduce the area of the thermal plume[12] and enable the fish to avoid the heated water without leaving the shallow water zone. Another alternative is to extend the condenser discharge canal structure into the lake beyond the shallow water beach zone. At the Palisades site, this extension of the structure would be about 2,000 feet to reach depths of about 20 feet. This alternative eliminates the shoreline thermal plume, although precautions must be taken to induce a rapid mix of the heated water in order to minimize the possibility of the thermal plume spreading back to the shore zone.

The periodic addition of chlorine as sodium hypochlorite to the once-through cooling water has an adverse impact due to the toxicity of the chloramines formed when free chlorine and nitrogenous matter react (see Chapter V.B. and V.C.). The chloramines formed are ingested by aquatic animals. The expected concentrations may be fatal to some aquatic life, and could eventually enter man's food chain. This impact can be minimized by using only that amount of hypochlorite needed to prevent the biological growths in the condenser and by limiting the treatment period to one hour per month and the concentration to 0.5 ppm residual chlorine at the outfall. However, this may only prolong the ultimate impact. Therefore, alternatives to the use of soluble poisonous chemical additions should be considered. Mechanical cleaning systems using circulating sponge rubber balls[13,14] or cyclic, automatic brush cleaning[15] could be backfitted to the steam condensers of the Plant. Neither of these alternatives should introduce any significant adverse environmental impacts. The applicant in Appendix XII-13 comments on these alternatives of using sponge balls in place of chlorine.

d. Comparison of Closed-Cycle and Once-Through Cooling

In the period since the Draft Detailed Statement was issued, the applicant has begun to investigate possibilities for modification of cooling tower equipment that would obviate the need to control corrosion by chemical methods. It now seems feasible to protect metal surfaces of the cooling tower components with plastic coatings and to use corrosion resistant alloys for the recirculating water pump components. If such modifications are adopted and chemicals are not used for corrosion protection, the principal impact of cooling towers on lake ecology will be caused by the recirculating water pumps (mechanical damage to organisms), the use of sulfuric acid to prevent scale formation, and chlorine (see V.C).

As a possible alternative, the Plant would be backfitted to incorporate two modifications which would be less expensive than cooling towers, and that would cause even less impact on the lake than that resulting from operation of the Plant with cooling towers as described above. First, adoption of the use of mechanical cleaning system to prevent fouling of turbine condenser tubes, such as is finding use in such plants as the Surry and North Anna Stations, would preclude the use of chemicals as necessary to the once-through mode of operation. Second, if the outfall were modified to discharge the recirculated cooling water through a multiport diffuser submerged to approximately 20 feet below the lake surface, and with the point of discharge extended to approximately 2,000 feet offshore, interruption of the shallow offshore corridor used by spawning fishes would not take place. Enhanced mixing, obtained by increased entrainment of colder lake water, would greatly reduce the extent to which the plume would be dispersed in the lake. Modeling studies for such discharges have been made for several plants recently.[34,35] Assuming the applicability to the Palisades Plant, without recirculating warm water to the Plant intake, the staff finds that at full power, the surface temperature of the lake resulting from the submerged discharge would be less than 2F° above the ambient lake temperature.

Asbury[34] has reported that the thermal burden to Lake Michigan from the operation of some 22 power plants projected to exist on its shoreline by the year 2000 will cause an increase in the average equilibrium temperature of the lake of 0.093°F. This results from an input to the lake of 66.4 gigawatts*. At a discharge rate of 5×10^9 Btu/hr, the Palisades Plant will contribute 2.19% of the projected increased thermal burden to the lake, and accordingly, could be responsible for an increase of the average equilibrium temperature by once-through cooling of 0.002°F. It is well known that the average temperature of Lake Michigan has decreased about 2F° since the turn of the century, and no evidence of a reversal of this trend has been observed. The probability that operation of the Palisades Plant with once-through cooling is likely to contribute to a general increase in the eutrophication of the lake by significantly increasing the thermal burden to the lake is therefore extremely low.

e. Costs of Alternative Cooling Systems

The estimated costs of some of these alternative cooling systems are shown in Table XI-1. The capital and operating costs for the cooling tower alternative, including backfitting charges, were provided by the applicant for the induced-draft mechanical wet cooling towers being designed for the Palisades site.[16,19,20] The high-velocity offshore discharge involves an investment of at least $1,000 per lineal foot of installed pipe. The applicant estimated over $3-million for a 2,200-foot discharge line, and Tennessee Valley Authority invested nearly $5-million at the Brown's Ferry Power Plant for about 5,000 feet of installed pipe for their diffuser system of thermal effluent discharge. The cost for the blowdown treatment system is estimated from manufacturers' literature for chromate or phosphate removal equipment. The cost of equipment for mechanically cleaning condenser tubes is based on experience at the TVA Brown's Ferry Plant. For the automatic brush cleaning technique,

*1 gigawatts = 1,000 megawatts

TABLE XI-1

RELATIVE COST OF ALTERNATIVES TO PRESENT ONCE-THROUGH COOLING SYSTEM OF PALISADES PLANT

Alternatives	Estimated Additional Cost	
	Capital	Operating
1. Higher velocity on-shore discharge	$\$1 \times 10^6$	none
2. Higher velocity off-shore discharge	$\$<5 \times 10^6$	small
3. Mechanical condenser cleaning	$\$<0.5 \times 10^6$	small
4. Cooling towers*	$\$20 \times 10^6$ (with backfitting charges)	$\$4.5 \times 10^6$/year
5. Blowdown chemical treatment (chromate or phosphate removed) 2×10^6 gpd = 7.3×10^8 gpy	\$<100,000	\$<50,000/year

* The applicant provided the estimated cost of cooling towers; the figures are for mechanical induced-draft wet tower.[20]

the manufacturer's literature indicates that the installation cost including backfitting of the necessary condenser reverse-flow piping would be of a similar magnitude. Other costs in Table XI-1 are estimates arrived at by comparing the complexity and relative magnitudes of each alternative.

The first three alternatives may be worthwhile objectives for any power plant using a natural water supply for once-through cooling, since the adverse impacts would then be as low as practicable in most cases. Since these alternatives have the shortest design and construction time following the observation of a significantly adverse impact, a delay period during which environmental impact data could be collected with the present system in operation would not place an unnecessary burdeon on the aquatic ecosystem, before a later commitment is made to an alternative.

The applicant has initiated plans for the design and construction of a closed-cycle cooling system using mechanical induced-draft, wet cooling towers. These towers are scheduled to be in service on or before December 31, 1973. Until then, the power plant will operate with the once-through cooling system. The cooling towers and associated equipment as presently envisioned will cost about $20-million (including backfitting costs), and will add about $4.5-million to the annual operating costs of the plant.[20] Mr. Bruce Tichenor,[17] in testimony before the Michigan Water Resources Commission on June 24, 1971, estimated the costs of backfitting cooling towers to a power plant like Palisades at $10 to $20-million, depending on a number of variables. He also calculated that these increased costs are the equivalent to about 0.5 mill per kWhr at the bus bar based on the Plant output. This is equivalent to an additional 0.1 mill per kWhr to the average customer, based on the applicant's 1970 annual power sales,[18] since the Palisades Plant will provide about 20% of the system capacity. This economic penalty is in addition to the adverse environmental impact of the cooling towers on the forest community of the sand dunes.

3. Alternative Radwaste System

The Plant, as built, permits the release of small amounts of radioactive material into Lake Michigan by way of the coolant water discharge and to the atmosphere by way of the stack. The applicant has, however, included additional treatment facilities in the design of the liquid radwaste system to reduce further the liquid radioactive wastes into Lake Michigan. These modified facilities will be operational by spring 1973.

a. Liquid Radwaste System

In Amendment No. 21 to the FSAR, dated March 1, 1971 and Amendment No. 24 "Special Technical Specifications Pursuant to Agreement" dated June 17, 1971, the applicant describes a modification of the liquid radwaste system which it intends to install at or before the end of the first fuel cycle. The modifications include the installation of two evaporators which will serve to reduce liquid radwastes (with the exception of laundry wastes) to levels comparable to the guidelines of proposed Appendix I to 10 CFR 50. Furthermore the applicant plans to recycle all clean and dirty wastes or to ship them offsite except for laundry wastes, which are expected to be a minor source of radioactivity. Thus, a discharge of approximately 60,000 lb/yr of unconsumed H_3BO_3, discharged at concentrations of $\leq$ 5 ppm with the present radwaste system will be reduced to essentially zero by use of the two evaporators, which will concentrate boric acid for recycle in the Plant.

Also the radioactivity released into Lake Michigan would be further reduced by the addition of demineralizers on the steam loop of the steam generation system. This would eliminate the need of blowdown of the secondary system and would be beneficial after the steam generators develop leaks from the primary to the secondary loop.

b. Gaseous Radwaste System

The present radioactive emissions included in the gaseous effluent from this Plant can also be technologically reduced. The applicant has agreed to add more holdup tanks for the radioactive fission gases to increase the holdup time from 30 days to 60 days. This will reduce the radioactivity of the ^{133}Xe by a factor of 30, at which time the long half-life ^{85}Kr would be the primary radioactive gaseous emission. The only known method of eliminating this radioisotope from the effluent is by storing it in pressurized cylinders. An approved method for storing these cylinders is not presently available. Finally, the addition of charcoal adsorbers in gas vent lines of Plant systems such as the holdup tanks, the containment building, the final storage area, and the turbine building would substantially reduce the gaseous radioactive iodine released to the environment from the stack. These charcoal adsorbers are used in most modern PWR facilities[20] and should be used to eliminate atmospheric releases from Plant ventilation.

c. Cost of Modifications of Radwaste System

In Chapter III, Table III-6 shows the anticipated releases of radioactive material in gaseous effluent based on the present and the modified gas processing system as proposed by the applicant. See Section III.D for further details on the radwaste modifications.

The applicant[20] has reported that the estimated capital cost of the radwaste modifications is about \$9 million and the estimated increased annual operating costs are \$1.2 million.

Costs of additional suggested changes in Sub-sections a. and b. above would not be unduly extreme in comparison to their effectiveness in reducing the quantity of radioactive effluent.

B. SUMMARY OF COST AND BENEFIT ANALYSES

1. Benefits

The primary benefits of the Palisades Plant are to provide electric capacity and to generate electric energy. Operation of the 700 MWe - Palisades Plant would be a benefit to all of the people of Michigan, by increasing the reliability of the electrical energy system during periods of peak load demand. Without the Palisades Plant, system deficiencies may cause industrial slowdown, which means reduced individual incomes, and may adversely affect critical public functions such as hospitals, water supply, and sewage treatment.

If the Plant operates at this capacity for 85% of the time, the output of electric energy will be about 5.2 billion kilowatt hours per year. Of the electric energy sold by the applicant, about 35 to 40% is used for residential purposes and the rest is about equally divided between industrial and commercial uses.

The taxable assessment of the Palisades Plant is about 75% of the total property assessment of Covert Township and about 12% of the Van Buren County property assessment.[25] The present tax paid by the applicant to the township is $900,000 per year, and this will double approximately when the Plant begins to operate ($18 million present value).[23] This income, a small part of which goes to Van Buren County, will enable the rural community to upgrade its school system. Other public services not obtainable with the previous tax income can be provided when desired; or, for the short term, the tax rate could be reduced. In addition, the annual payroll at this Plant would be about $0.5-million much of which would enter the economy of Van Buren County. Abandonment of the Palisades Plant would not place a financial burden on the community, since no significant programs have been started as a result of the potential tax income.[23] However, many of the employees would be forced to move elsewhere to find similar employment.

A recreational benefit has accrued from the addition to Van Buren State Park of 360 feet of lakefront property in an exchange of land with the applicant. Also, the State Park visitors have benefited by increased pedestrian safety and decreased highway noise resulting from the relocation of U.S. Highway 31 out of the center of the park property. A visitors' center, built by the applicant for public relations, will provide some educational benefit to the public, particularly to the school children of the area. Based on attendance at the neighboring public parks, it is reasonable to assume that there will be about 100,000 visitors per year.

2. Generating Costs

The total capital outlay for the Palisades Plant has been about $171,000,000. The costs of operation and maintenance at 0.5 mills per kilowatt hour amount to about $2,600,000 per year. The costs of nuclear fuel at about 2.1 mills per kilowatt hour amount to $10,900,000 per year. The present worth of these annual costs for 30 years of operation, based on a discount rate of 8.75% per year, is $142,000,000. When this is added to the capital outlay, the total generating costs become $313,000,000.

The incremental cost for the addition of mechanical draft cooling towers is estimated at $20,000,000 for capital outlay and $4,500,000 per year for operating costs. The total increment in terms of present worth for 30 years of operation would then be about $67,000,000.

The alternative of constructing a fossil-fuel plant over the next five years and then operating that plant would greatly increase generating costs. Because of the escalation of power-plant construction costs, the capital outlay for a new conventional coal-burning or oil-burning plant would actually be greater than it was for the Palisades Plant. A combined-cycle oil-burning plant might be somewhat less expensive to construct. The predominant effect is that the fuel costs for any coal-burning or oil-burning plant would be several times that of the Palisades Plant. (See the comparable analysis for the proposed Midland Plant of the Consumers Power Co.[38])

3. Land Use

Construction of the Plant was accomplished with little adverse impact on the local terrestrial environment. A minimum amount of land was disturbed during construction. An active effort is currently underway to landscape the disturbed area to enhance the appearance of the site.[19] The unused acreage on the site will be preserved in its natural condition, and nature trails, when established, will enhance public enjoyment of the area. Since most of the construction labor force lived within driving distance, there was no significant influx of short-term residents, and therefore, no adverse impact on housing and schools or other public services. There was some overcrowding of rental facilities in South Haven, especially during the summer months when both construction workers and summer tourists sought temporary housing. There was no significant change in civilian life patterns within the community nor an increase in commercial activity; and apparently no new business establishments were begun as a direct result of the construction activity. The delivery of much of the construction material on a railroad spur relieved the local roads from heavy construction use, and thus prevented the development of any major damage.[23,24] About a total of 2,225 acres of land were cleared for transmission lines. The aesthetic impact is not great although construction of the cooling towers may have a minor additional effect.

Construction of the cooling towers would increase the adverse effect on the dunes area. Operation of the tower would cause some icing and fogging, mainly onsite. The noise level onsite would be increased, but may not be noticeable at the Plant boundary.

4. Water Use

With the present once-through cooling system, the Plant will use about 405,000 gpm of water from Lake Michigan and return it to the lake at a temperature of 25 F° above the intake temperature. (See Section III.D.) In the thermal plume, the excess isotherm for 3 F° above ambient will extend about 8,500 feet offshore and cover an area of about 370 acres when there are no lake currents (bell-shape plume).

With the cooling tower (closed-cycle) system the Plant will use much less lake water. The evaporation and drift losses will total about 12,300 gpm, a relatively negligible loss. About 60,000 gpm, used to dilute the 1,320 gpm blowdown, will be discharged to the lake at a temperature of < 5 F° above ambient.* In the case of a 5 F° excess isotherm at the outfall the predicted thermal plume would have a 3 F° excess isotherm that extends about 630 feet from the outfall and covers an area of < 1.8 acres when there are no lake currents.

The discharge of chemicals and heat with the once-through cooling system is not expected to have any effect on water quality except as related to biota. With the cooling tower operation, as shown in Table XI-2, total dissolved salts and toxic chemicals from the blowdown will be deposited in the lake water that otherwise would not be there. Corrosion inhibiting chemicals could be removed by blowdown treatment (see Section XI.2.a). It is also possible to design the towers so as to reduce the chemicals needed.

* With 60,000 gpm dilution, the diluted blowdown temperature is expected to be less than 1 F° above ambient.

5. Biological Impact

Operation of the Palisades Plant with once-through cooling may have some adverse ecological impact on the aquatic life in Lake Michigan near the discharge structure. However, the environmental cost is expected to be quite small. This is partly due to the fact that the impacts described in previous chapters are significant only when sufficiently large populations of animals and/or plant life are present in the affected areas. Available information indicates that present populations are small in the lake adjacent to the Plant site. Increased populations in the future may increase the environmental costs. The low environmental cost is also due to the short reproduction cycle of the most affected organism, the algae. Quantification of the environmental cost of the once-through cooling system is difficult at this time due to the lack of well-defined damage to the aquatic ecosystem.

The estimated biological damage due to impingement and entrainment for the once-through cooling system is about 60,000 pounds per year. The estimated damage for the cooling tower system is about 8,500 pounds per year. (See pages V-6 and V-78.)

Terrestrial environmental impacts are also difficult to quantify due to lack of experience and the large number of variables involved. However, the regulatory staff's analysis indicates that the potential for total damage to terrestrial and aquatic ecosystems particularly to the unique sand dune area due to the cooling towers is at least as great as the potential for damage to aquatic systems due to the once-through cooling system.

With the present knowledge of the aquatic community of Lake Michigan at the Palisades site and the rather minimal impact foreseen by operation of the Plant as built, there does not appear to be sufficient ecological justification for the additional resource investment (and subsequent increased cost to the consumer) necessary to provide cooling towers. The ecological impact of each cooling system is of comparable significance.

Operation of the Palisades Plant with the once-through cooling system does add to the total heat burden placed on Lake Michigan. However, the staff's analysis shows that this heat burden does not have a significant adverse impact on the lake in the vicinity of the site, nor will the lake's average temperature be measurably increased by the operation of the Plant. The concerns expressed for the potential overburdening of Lake Michigan with thermal effluents has been in the long-term related to a large number of power plants projected for future years up to the year 2000. As seen earlier, these power plants are not expected to produce a significant effect on lake populations from thermal discharges. Any new regulations should be imposed first on future planned construction and second upon facilities shown by good scientific evidence to be degrading the environment to a significant degree.

6. Radiological Impact

From the radioactive releases to the environment under controlled conditions, the radiation doses to various groups of biota and man based on operation of the Plant with the present radwaste system are summarized in Tables V-6 and V-7. As noted in the text accompanying these tables, the annual cumulative dose to the 1,000,000 population living within a 50-mile radius of the Plant is estimated to be about 3 man-rem and an average annual dose to an individual of 0.003 mrem. The corresponding annual background dose is 100,000 man-rem to the general population and 0.1 rem to an individual. The assessments of the radiation exposure to the plants and animals of the environment (aquatic and terrestrial) indicate there is no significant adverse impact based on the design releases listed in Tables III-7 and III-8.

With the proposed modifications of the present radwaste system, releases of liquid radwastes will essentially be zero. The radiation doses from radioactive gaseous effluent will be reduced to an estimated value of less than 1 man-rem for the total annual cumulative dose to the population living within a 50-mile radius of the Plant, and an average annual dose to an individual of 0.001 mrem (1 μrem).

The financial investment of these improvements ($9,000,000 - capital costs and $1,200,000 annual operating costs) is not considered to be great relative to the overall capital investment for the entire facilities and relative to the benefits to man and his environment over the long term. These improvements will be added in 1973; however, the Plant can operate with its present system with no significant adverse impact on the health or safety of man and biota.

7. Cost-Benefit Balance

In Table XI-2 the estimated monetized costs of the Plant are summarized, for both the present once-through cooling and the mechanical draft cooling tower systems. Examination of Table XI-2 reveals that the monetary cost of the cooling towers is $67,000,000 (present value) greater than the once-through cooling system. The environmental costs associated with the two systems differ in the following respects:

a. Economic Impact

The construction of the Palisades Plant has been completed since spring 1971 and on November 20, 1971 the applicant obtained a limited operating

TABLE XI-2

COST SUMMARY FOR ALTERNATIVE
HEAT DISSIPATION SYSTEMS

[Note: Costs are in dollars of present value, based on 30 years of operation and a discount rate of 8.75% per year.]

A. MONETARY COSTS

	Once-Through Cooling	Mechanical Draft Wet Cooling Towers
1. Generating Costs	$313,000,000	$313,000,000 (with reduced electrical output)
2. Incremental Costs	(Reference Case)	
a. Capital Cost	---	20,000,000
b. Operating Cost	---	47,000,000

B. ENVIRONMENTAL COSTS

	Once-Through Cooling	Mechanical Draft Wet Cooling Towers
1. Land Use		
a. Area modified (see Fig. II-1 and Sec. IV.B.1.)	30 acres	32.3 acres
b. Ambient noise	Negligible	Minor effect on site
c. Fogging and icing	None	Possible effect on dunes and fruit farms
d. Salt deposition (from drift)	None	Possible effect on dunes (see Table V-4)
e. Transmission Lines	5 acres (dune area)	5 acres (dune area)
	2,250 acres (farm land)	2,250 acres (farm land)
2. Water Use		
a. Destruction of entrained biota	60,000 lbs/yr	8,500 lbs/yr
b. Water continuously removed from lake	405,000 gpm	73,840 gpm

	Once-Through Cooling	Mechanical Draft Wet Cooling Towers
c. Consumptive use of lake (evaporation, drift) water	<8,000 gpm	12,300 gpm
d. Area enclosed by 3F°-excess isotherm in thermal plume	370 acres	< 1.8 acres
e. Concentrated salts discharged to lake	None (see Tables III-9 and 10)	Increased TDS concentration (see Tables III-9 and 10)
f. Free chlorine discharged to lake	0.5 ppm at 405,000 gpm for 1 hour/month	0.022 ppm at 60,000 gpm at 1 hour/day
g. Corrosion inhibitors discharged to lake	None	Chromate added (see App. V-1)
h. Other biocides	None	0.036 ppm Zn, 0.27 ppm PO_4 at 60,000 gpm (see Table III-10)
3. Air Emissions		
a. Radioactive Gases	Same	
b. Plume (fog, water vapor)	Negligible	12,300 gpm of evaporated water for fog formation 20 gpm drift with concentrated salts
4. Annual Radiological Impact		
a. Cumulative dose to people in 50-mile radius from Plant	3 man-rem	
b. Average dose to individual living within 50-mile radius of Plant	0.003 mrem.	
c. Whole body dose to individual at site boundary	0.57 mrem	
d. Thyroid dose from ingestion of water at South Haven	1.4 mrem	

	Once-Through Cooling	Mechanical Draft Wet Cooling Towers
e. Child's thyroid dose from iodine in cow's milk from nearest dairy farm 3 miles in SSE sector	1.3 mrem	
f. Child's thyroid dose from drinking 1 liter of milk per day from cow at the potential nearest grazing land (2 miles in SSE sector)	2.6 mrem	
5. Biological and Chemical Impact		
a. Annual amount of chemicals added to lake*	1,220 lb chlorine 60,000 lb boric acid	242 lb chlorine @ 0.222 ppm 6,950 lb Zn @ 0.026 ppm 69,500 lb PO_4 @ 0.26 ppm 5,800 lb CrO_4 @ 0.022 ppm** 5,800,000 lb SO_4 @ 22 ppm
b. Added chemicals (See Section V.C)		
c. Nutrient for algal growth added to lake		Increased concentration of PO_4 by 20 X - promotes growth of blue-green algae Increased concentration of SO_4 promotes growth of Desulfovibrio sp.

* Chlorine added 1 hour/month in once-through cooling and 1 hour/day in cooling tower operation. All other cooling tower chemicals added continuously. Boric acid added intermittently; boric acid concentration will be reduced by 0 ppm with modified radwaste system.

** Assuming the concentration of the excess chromate in the blowdown before dilution with 60,000 gpm lake water is 1 ppm.

license to operate up to 20% of rated power. Another limited operating license to operate up to 60% of rated power was obtained from the Commission on March 10, 1972. Based on the staff's testimony and supporting documentation[29] dated December 30, 1971 presented in the Hearing before the Atomic Safety and Licensing Board on January 25-26, 1972, the costs in a delay in the licensing action for limited operation at 60% of rated power amounted to about $2,000,000 per month. Furthermore operation at 100% of rated power would eliminate this cost in delay to both the applicant and the consumers of electricity.

With the Plant in full power operation, the applicant will also be paying about $1.8 million per year of property taxes to the county and the township. The annual payroll would also be about $0.5 million, much of which would enter the economy of the local area. Benefits gained by the use of the visitors' center have been estimated to be about 100,000 visitors per year.

b. Land Use:

Cooling towers require about 2.3 more acres of dunes to be modified. Cooling towers introduce some noise on site and possible minor effects of fogging, icing and salt deposition.

c. Water Use:

The once-through system removes about 7 times as much lake water and has the potential to destroy about 7 times as many biota (mainly plankton) as the cooling tower system. The cooling tower has a consumptive use of over 12,000 gpm and results in discharge of concentrated salts and corrosion inhibitors into the lake which are toxic to biota. The thermal influence from the discharges of the once-through cooling system is much larger than that of the cooling-tower blowdown.

d. Air Emissions:

Except for the possible fogging caused by cooling tower evaporation, both cooling systems have equal environmental effects on the atmosphere.

e. Radiological Impact:

Both systems have some impact. The modified radwaste system will assure that the radioactive releases will meet the proposed Appendix I of 10 CFR 50 and thereby reduce the annual radiological impact to less than 1 μrem to an individual and 1 man-rem for a population of 1,000,000 living within a 50-mile radius of the Plant.

f. Biological Impact

As discussed above in this Statement, both systems have some adverse impact on aquatic biota and other ecosystems in the local area of the Palisades Plant, but these impacts are confined to a relatively small area of the total area of Lake Michigan. However, the intermittent discharge of residual chlorine in the circulating cooling water in the once-through system and the continuous thermal discharge at an excess elevated temperatures of 25 F° above ambient are not expected to reduce the overall aquatic productivity and the population level of the entire Lake Michigan, nor along the eastern shore of lower Michigan. The heat burden of the thermal input into the lake is localized and will not alter the average temperature of the lake over the 40-year lifetime of the Plant. All the heat input will eventually be dissipated into the atmosphere and no adverse climatic changes should occur from the heat generated from the Plant.

In regards to the cooling tower system, the continuous discharge of concentrated toxic chemicals and total dissolved solids directly into Lake Michigan, even with the dilution of the concentrated salts with lake water, will result eventually in a deleterious burden of sustaining chemicals into the lake which have the potential of causing long-lasting adverse effects on water quality and on aquatic biota, particularly in the vicinity of the Plant. The cooling tower plume and drift also have the potential of damaging the terrestial biota located on the sand dunes. Thus these potential effects are of significance to warrant further investigation into alternatives to the planned modifications of the once-through cooling system.

In effect, use of the cooling towers reduces the size of the thermal plume and the mass of entrained biota that may be destroyed in the cooling system, but increases the toxic chemical input into the lake. Briefly, the thermal impact on aquatic biota is reduced but the chemical impact increased.

In summary the regulatory staff's assessment of the Plant operation at 100% rated power of 700 MWe indicates:

Once-Through Cooling Mode of Operation

1) On technical grounds the adverse impacts to the environment will be of little significance.

2) After December 31, 1973, it will not be possible to comply with the thermal discharge standards for Lake Michigan recommended by the Environmental Protection Agency. (See page III-27)

3) It will however, be possible to comply with the thermal discharge standards for Lake Michigan established for the Palisades Plant by the State of Michigan Water Resources Commission.

4) As described in Section V.C.1. a modified ecological and environmental monitoring program[21,22] will proceed for the first two years of operation with the once-through cooling system to examine the localized and overall effects on the environment of Lake Michigan and the applicant's site and surrounding areas.

5) Alternative Plant design and operating techniques are feasible to minimize the local effect from the thermal, chemical, radioactive, and other discharges and to reduce the mechanical effects on aquatic and terrestrial biota and environmental effects on man.

6) Backfitting modifications of the Plant's once-through cooling system to reduce the local effects of the thermal and chemical discharges can be accomplished after operation has begun at costs that are less than compared with the costs associated with the installation of mechanical draft cooling towers.

<u>The Mechanical Draft Cooling Tower System</u>

1) The applicant has demonstrated its willingness to install and operate mechanical draft cooling towers through an agreement with the intervenors.

2) The regulatory staff has found that the assessment of the mechanical draft cooling tower operation, which does not include chemical treatment of the blowdown, may have a more adverse impact on the environment than would occur with such treatment primarily from the continuous discharge of phosphate, zinc, chromate, and sulfate ions into Lake Michigan and salts in the drift onto the sand dunes.

3) The regulatory staff approves of the applicant's efforts to reduce the thermal impact to Lake Michigan to an insignificant degree. The current assessment shows that although the intent of this effort is to ameliorate adverse effects of thermal discharges, it is unnecessary.

4) Alternatives are available for treating blowdown, decreasing the chemical concentrations by further dilution, constructing and operating settling ponds, utilizing demineralizers, fabricating metallic components of the cooling towers from corrosion-resistant alloys, and using other cooling devices in order to minimize the potential long-term impacts from blowdown discharges and drift. The applicant is investigating procedures and techniques to reduce chemicals in the blowdown.

5) An ecological and environmental monitoring program will proceed to examine the impacts to Lake Michigan and to the dunes from blowdown and drift during the first 5 years of operation of the Plant in the closed-cycle mode. Such operation will not foreclose options to treat the chemical discharge from the towers nor to exclude chemical treatment entirely by backfitting the towers with corrosion-resistant components.

6) The applicant shall be required to implement the program described above to eliminate or significantly reduce such detrimental effects as might be revealed by the monitoring program.

g. Resources Impact

During operation of the Palisades Plant, a consumption of 2.74% enriched uranium would involve about 1,300 metric tons (1,450 U.S. tons) based on the production of 24,000 MWt-d per metric ton of uranium.

h. Conclusion

The staff finds that the environmental impact from the thermal, chemical, radioactive discharges and mechanical effects caused by the once-through cooling system is of comparable significance as that from the chemical blowdown, fogging, and icing from the plume during the utilization of mechanical-draft cooling towers. Inasmuch as the impact of either cooling system is considered by the staff to be minimal, the staff has concluded that operation of the Plant with the proposed cooling towers is acceptable as conditioned above.

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XII. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT DETAILED STATEMENT ON ENVIRONMENTAL CONSIDERATIONS

Pursuant to paragraph A.6 and D.1 of Appendix D to 10 CFR 50, the Draft Detailed Statement was transmitted with a request for comment to the: Advisory Council on Historic Preservation, Department of Agriculture, Department of the Army, Department of Commerce, Environmental Protection Agency, Federal Power Commission, Department of Health, Education, and Welfare, Department of Housing and Urban Development, Department of the Interior, Department of Transportation, Governor of the State of Michigan, State of Michigan Department of Natural Resources, Public Utilities Commission, Department of Public Health, Board of County Commissioners, Van Buren County, and Township of Covert. In addition the Commission requested comments on the Draft Detailed Statement from interested persons by a notice published in the Federal Register on March 10, 1972 (37 F.R. 5138).

Comments in response to the requests referred to in the preceding paragraph were received from the Advisory Council on Historic Preservation, the Department of Agriculture, the Department of the Army, the Department of Commerce, the Environmental Protection Agency, the Federal Power Commission, the Department of the Interior, the Department of Transportation, State of Michigan Department of Natural Resources, Department of Public Health, and Township of Covert. The applicant in three separate communications has also responded to comments from these agencies.

Our consideration of comments received is reflected in part by revised text in other sections of this Statement and in part by the following discussion.

A. SITE SELECTION

Comments were offered from the EPA, DOT, and the Township of Covert, with regard to the selection of the site by the applicant based on economic considerations. Although the applicant selected its Palisades site and the use of nuclear power based primarily on economic considerations, the applicant has carried out an extensive landscaping and stablization program of the sand dunes in order to enhance the appearance of the site and preserve the formation of the sand dunes. The applicant has already started construction of the cooling towers by building the foundation for the towers and will landscape the immediate area around the towers after construction is completed. Meanwhile the applicant has continued to landscape and plant vegetation native to the area on the remaining areas of its site. A large share of the site has been forested and dune grasses planted to restore the site to its natural surroundings.

B. HEAT DISSIPATION SYSTEMS

1. Once-through Cooling System

Comments were offered from EPA, Interior, and the Township of Covert with regard to the evaluation of the once-through cooling system versus the mechanical draft cooling tower system in terms of thermal discharges from the Palisades Plant.

Section III. D.1 has been modified to reflect additional information on both a qualitative and a quantitative description of the thermal discharges from the once-through cooling system. Both empirical and analytical relationships were used to obtain a quantitative description of the size of the excess isotherms of the thermal plume.

The staff has utilized two approaches in its quantitative plume description: (1) a study employing a mathematical model by Motz and Benedict in conjunction with empirical relationships developed by Pritchard and (2) a study combining empirical relationships developed by Asbury and Frigo and by Pritchard with experimental data collected by personnel of Argonne National Laboratory. Details on assumptions, mathematical equations, procedures, and other specifications are also presented in Section III.D.1.

Information is presented as to the size of the thermal plume as it is dispersed into Lake Michigan at different times of the year. The applicant under its Technical Specifications for operation of Palisades Plant at 60% of full power has observed a sinking plume during this past spring and is determining the characteristics of the thermal plume.

In order to determine the impact of the thermal discharges on the aquatic biota, the applicant shall be required through the Technical Specifications to determine detailed characteristics of the thermal plume during full power operation prior to installation of the cooling towers. The intent is to establish baseline information for purposes of comparison of the environmental impact of two alternate cooling systems.

EPA also commented on the formation of a thermal bar in the winter months. As stated in Section II.E and III. D.1, the staff believes that the physics of the phenomenon dictate that mixing across the thermal bar must occur and dissipation of the Palisades effluent should not be inhibited. The study of multispectral infrared scanning of thermal effluents from three power plants showed no evidence of any water masses that could be attributed to the effect of warm water discharges from these plants into the lake. The Michigan

Department of Natural Resources also was concerned about the thermal bar but as stated in Section III.D.1.c, the thermal plume may disrupt the thermal bar phenomenon resulting in a significant increase in the onshore temperature regimen. The effects of density underflow could be disruptive in the thermal bar formation. From this a potential of affecting fauna and floral inhabitants of the inshore zone could result. The Michigan Water Resources Commission (MWRC) is also concerned with the effects of the density underflow on the spawning and development of white fish, ciscoe, and lake trout. The applicant will be required to observe and measure the properties of the thermal plumes and determine the effects on aquatic biota during the environmental monitoring program with the once-through system.

As stated throughout this Statement, thermal discharges from the present once-through cooling system will not be able to meet the presently proposed Lake Michigan Enforcement Conference Recommendations. However, Item II.2 of these Recommendations states that "Plants not in operation as of March 1, 1971 will be allowed to go into operation provided they are committed to a closed cycle cooling system construction schedule approved by the State regulatory agency and EPA. In all cases construction of closed cycle systems and associated intake and discharge facilities shall be completed by December 31, 1974 for facilities utilizing natural draft towers and December 31, 1973 for all other types of closed cycle systems."

2. Mechanical Draft Cooling Tower System

In regards to operation of the Palisades Plant with mechanical draft cooling towers, the Township of Covert has expressed its concern over the amount of water (1,500,000 gpd) evaporated and the drift that could result in a buildup of residues on the ground in the surrounding area. From this, fog, icing and possible snowfall may be increased. The Township also states its concern by the following "The increase in cost to the user of electricity when it is questionable if the cure is any better than the supposed decrease (thermal pollution of Lake Michigan)." It goes on to recommend that the towers should be de-activated in the winter months to conserve electricity and eliminate the amount of chemicals going into Lake Michigan through the tower blowdown process. The staff has stated in Chapter V that fogging and icing from the cooling tower plume would be primarily limited to the Plant site since the towers will have an elevation about equal to that of the sand dunes and will be located in the valley of the sand dunes. The remarks on deactivating the cooling towers during winter months to reduce fogging and icing and to eliminate the chemicals are well taken. As experience on operating the towers is gained by the applicant, and in accordance with the thermal discharge recommendations for Lake Michigan, de-activation of the cooling towers during winter months may be possible.

As discussed below, in Appendix XII-13, the applicant is looking into the matter of reducing the amount of chemicals in the blowdown by proper selection of materials for construction of the cooling tower, by eliminating the use of corrosion inhibitors, and by avoiding discharge of zinc and phosphate into the environment. The technical feasibility of doing so has been established and an economic study is in progress by the applicant. (These activities will be responsive to EPA's comments regarding the need for a blowdown treatment system.) The Michigan Water Resources Commission refers to section 6 of the existing Order of Determination for the Palisades Plant for the effects of chemicals from the blowdown; however, specific restrictions may be necessary in the form of an amended Order at a later date when the applicant has decided on the specific chemicals to be used within the towers. To minimize the drift of chemicals, drift eliminators will be requested in the cooling towers. The MWRC also is concerned with possible releases of phosphates in meeting the State's recommendations to control of phosphate. Since treatment systems are available to reduce phosphate below 4 ppm, the applicant will be required to employ such techniques to limit phosphate concentrations to below 4 ppm.

C. WASTE TREATMENT AND EFFLUENT DISCHARGE AND IMPACT

Comments have been received from DOI, DOC, EPA, and Michigan Department of Public Health with regard to the evaluation of the source term of radioactivity to be discharged in liquid and gaseous effluents as a result of various modes of operation of Plant equipment.

The Commission's regulation, 10 CFR Part 50.34a, requires the applicant to describe the equipment and procedures for the control of radioactive material in effluents to unrestricted areas. This regulation of 10 CFR 50.36a requires that equipment installed in the radwaste system be maintained and used. The estimated annual releases of radioactive material in effluents from the Palisades Plant listed in Chapter III.D.2 were developed by the staff on the basis of experience at similar operating reactors and consideration of the additional waste treatment equipment.

In the judgment of the staff, the liquid and gaseous radwaste equipment should be utilized to reduce radioactive releases to a minimum. However, proper maintenance of the equipment is necessary to assure optimum performance of the equipment.

The source term presented in the Draft Detailed Statement has been modified to include the source term for gaseous releases from the Auxiliary Building and reflects the changes in iodine releases. In response to EPA's comments, Table XII-1 lists the principal conditions and assumptions used in estimating the amount of radioactive material to be released in the effluents from the Palisades Plant.

In response to a number of comments on radioiodine, for the purpose of calculating permissible releases, the MPC for halogens and particulates with half-lives longer than 8 days will be reduced by a factor of 700 from those listed in 10 CFR 20, Table II in Appendix B. The limit is based on the highest long term value of χ/Q which occurs at the south edge of the site and is approximately 2×10^{-12} sec/cc. It also considers a cow grazing 5 months of the year at a point 3 miles from the Plant in the SSE sector. The value of 0.8 Ci/yr referred to in Table III-5 of the Draft Detailed Statement is incorrect. The value should be 2.2 Ci/yr. This corresponds to the iodine-131 release limit of 2.25 Ci/yr derivable from the formula set forth in § 3.9 of the Technical Specifications as stated by the applicant in Appendix XII-13.

In a letter to Dr. P. A. Morris dated November 23, 1971, the applicant also has made provisions for monitoring effluents by installing a separate monitor to replace the stack monitor in the originally proposed system and to accomplish the identical purpose of monitoring releases from this source. In addition, the Technical Specifications for the Palisades Plant will require that measurements be made and analyses be performed using methods, procedures, frequencies and instrumentation comparable to the guidelines set forth in the Commission's Safety Guide 21, "Monitoring and Reporting of Effluents from Nuclear Power Plants," dated January 1972.

According to Amendment 21 to the FSAR, the modified radwaste system will permit the radioactive steam generator blowdown at a leakage rate of 20 gpm to be routed to the secondary waste evaporator. The Special Technical Specifications of June 21, 1971 calls for limiting the releases of liquid effluents to 10% of 10 CFR 20. This includes releases from the steam generator blowdown.

In regards to the Michigan Department of Public Health's comment on radioactive laundry wastes, the applicant has stated that contaminated clothing used as a protective cover for most operator functions can be disposed of as solid wastes. However, regular protective clothing used for maintenance must be laundered. The applicant estimated that a cost of $40-50,000 per year would be involved if all clothing was disposed of rather than some being laundered. The effluents from the laundry will meet the proposed Appendix I to 10 CFR 50. The applicant is investigating alternatives for reducing laundry waste radioactivity.

Table XII-1

PRINCIPAL ASSUMPTIONS USED IN ESTIMATING RELEASES OF RADIOACTIVE EFFLUENTS AT PALISADES PLANT

Thermal Power	2,200 MWt
Plant Capacity Factor	0.8
Failed Fuel*	0.25%
Leak of Primary Coolant in Steam Generators	20 gpd
Leak of Primary Coolant to the Auxiliary Building	20 gpd (gas)
Leak of Primary Coolant to the Containment	40 gpd (gas)
Steam Leak to Turbine Building	5 gpm
Steam Generator Blowdown Rate (continuous)	10 gpm
Frequency of Containment Purge times/yr	4
Waste Gas Holdup for Decay	
Present Systems	30 days
Modified System	60 days
Iodine Partition Coefficients	
Primary Coolant	
Leakage to Containment	0.1
Leakage to Auxiliary Building	0.0001
Secondary Coolant	
Steam Generator	
Internal	0.01
Blowdown Vent	0.05
Condenser Air Ejector	0.0005
Steam Leak to Turbine Building	1

*This value is constant and corresponds to 0.25% of the operating power fission product source term.

On the subject of tritium, the applicant conducted a study to determine the tritium inventory buildup in the reactor coolant during the life of the Plant, once the modified liquid radwaste system is installed. The concentration of any tritium released to the environment will not exceed that concentration specified in Appendix I to 10 CFR 50. The same amount of tritium will be produced and released to the general populace over the life of the Plant with the original or modified radwaste system. No tritium should be released from the Plant via the cooling tower circuit since any tritium will be recycled within the Plant.

In terms of direct radiation exposure, no significant direct radiation from PWR will result, except from borated water storage tanks located on the roofs of the auxiliary building. These tanks are expected to contain only tritium so no exposure to visitors at the visitor's center should result. The exposure to persons include 0.018 mrem to a person spending 500 hours per year on the beach and 0.013 mrem per year to a fisherman spending 500 hours per year at 100 feet from shore.

D. ACCIDENTAL RELEASE OF RADIOACTIVE LIQUID WASTES TO LAKE MICHIGAN

Radioactive liquid releases in the Palisades Plant are contained within Class I structures. Failure of equipment within these structures would not lead to a release of radioactive liquid to the environment. The quantity of low-level liquid radioactive materials outside Class I structures is very small and release of this material would not affect substantially the environmental impact determined for routine operation of the Plant.

Radiation process monitors are set to close off valves to prevent inadvertent releases to the environment. Thus by reducing the probability of occurrence of a particular accident through proper quality assurance, equipment, structures and correct operational procedures, the environmental risk becomes very low from any of the classes of accidents considered.

E. ACCIDENTAL RELEASE OF RADIOACTIVE WASTES TO THE ENVIRONMENT DURING TRANSPORT OF RADIOACTIVE MATERIAL

Details concerning the procedures to be used when a spilled shipment occurs are presented in the Commission's regulations 10 CFR 71 and the Department of Transportation's regulations in 49 CFR 170-179. The carrier of the radioactive material will be responsible in handling any accidental spillage of radioactive material. The staff believes the low probability of any radioactive contents being spilled does not justify developing detailed procedures for the wide range of potential conditions that might arise in case of leakage. The staff considers it adequate to provide the general procedures for dealing with spills as set forth in DOT's regulations (49 CFR §§ 171.15, 174.566, 174.588, 175.655 and 177.861). Chapter VI gives further details on safety practices to avoid accidents.

In reference to EPA's comments on the need for additional evaluation of the environmental risk from transportation accidents, EPA noted that the AEC is making a thorough analysis of the probabilities and consequences of such accidents. The staff is making a general analysis of the environmental effects of transportation. A report on this subject is nearing completion and is expected to be issued soon.

With respect to the tritium-contaminated liquid waste, if the liquid is solidified before disposal, the present Statement covers the transportation of such material. If the applicant decides to ship the tritium-contaminated liquid waste offsite for storage or burial, a further assessment of the environmental effect of that transportation would be needed.

F. ALTERNATIVE METHODS TO CONTROL CHLORINE DISCHARGES

In response to comments from EPA, in Chapter V.C. more detailed information on the toxicity of chlorine on aquatic biota has been presented than was presented in the Draft Detailed Statement. Since chlorine discharges are limited to an intermittent process of treatment, the releases should be limited not only in concentration level of 0.5 ppm for a total of one hour per month, but that at least the treatment process should not exceed 30 minutes per day. The applicant has responded to this question by considering recirculating sponge balls, automatic brushes, and manual brush cleaning. Since the brush technique does not appear practicable, the applicant states that it intends to pursue the possibility of substituting the method of recirculating sponge balls; however, a potential problem of shredded balls could result. The applicant could also consider the use of sulfur compounds to decompose the chlorine and to chlorinate during daytime to take advantage of the sunlight and during high wave action to disperse the chlorine plumes. Once the cooling towers are in operation, the chlorination of cooling tower water will be carried out such that the cooling tower blowdown will be secured for a period of time during and after the treatment so as to expose the chlorine to sunlight and air to decompose the chemicals. Operating experience of the cooling tower will be used to determine the length of time the blowdown can be secured and the rate of decomposition of chlorine.

G. NONRADIOACTIVE GASEOUS DISCHARGES

During the construction of the cooling towers and the modified radwaste system, debris and dust will be created. In order to minimize the effects of the construction activities, which will create air particulates, the debris will not be burned in an open fire but be disposed of by a commerical service utilizing land fill techniques.

Air pollutants emitted from auxiliary boilers, heaters, concrete batching plants, and diesel generators will be required to meet State and local requirements. The Palisades Plant has two diesel generators which are provided as emergency sources for onsite power. These diesel engines are normally on standby; however, they are operated periodically (2 hours per month) as part of the surveillance testing required for emergency equipment. The diesel generators each have a continuous rating of 2500 kW. As stated in Section III.D.4, the Plant gases will pass through a HEPA filter to remove particulates before discharge to the stack. The fuel used in the diesel engines will be limited to low sulfur oil. The gaseous effluents will consist of combustion products, NOx, SO_2, H_2 and N_2. Trace quantities of common organic solvents such as CCl_4 will be emitted from the Plant chemistry laboratories.

H. BIOLOGICAL EFFECTS AND ENVIRONMENTAL MONITORING

In response to comments on the biological effects from operation of Palisades Plant, additional information has been presented on the subjects of unscheduled shutdowns and subsequent cold kills, thermal effects on fish, primarily lake trout, whitefish, and perch, and chlorine effects on aquatic biota. The applicant is counting the numbers of fish impinged on the intake traveling screens and the results indicate that only on a few days did the number of fish caught exceed 100. On many days no fish were caught at all. The applicant will continue keeping records of the number and size of the type of fish caught as required in the Technical Specifications. If the numbers of fish collected becomes excessive, the applicant shall be required to provide protective means such as covering of the intake crib with screens to reduce impingement.

The applicant will be required to regulate the rate of scheduled shutdowns to minimize the problem of sudden shock of reduction in temperature of the thermal discharges which may have attracted fish near the Plant. Information on this subject has been presented in Section V.C. and in Table V.3.

Damage to biota will occur from entrainment in the cooling water as it passes through the once-through cooling system. The applicant through its ecological monitoring program shall be required to determine the significance of the damage. Once the cooling towers are installed, the significance of damage from entrainment by dilution of the blowdown can also be determined. Operating experience can be used to determine if the 60,000 gpm amount of Lake Michigan water is necessary or whether it can be reduced. The concentrations of chemicals and radioactive materials discharged will be increased with reduction in the dilution water but the releases may still be small such that reduced dilution can be carried out.

Additional information on thermal effects on specific fish has been added in Appendix V-2. This includes thermal sensitivity of fish during migrations, particularly larvae and juveniles and thermal discharges on spawning of fish.

The ecological monitoring program will be spelled out in detail in the Technical Specifications using the information provided in this Statement. The applicant has and shall be required to conduct an extensive ecological monitoring program in cooperation with State and Federal Fish and Wildlife Services. The ecological program shall be designed to obtain pertinent data in order to assess the relative impacts of the once-through cooling system and the cooling tower system. The recommendations on the aquatic ecological program made by EPA are well taken and will be included in the Technical Specifications for the full power operating license. The applicant has also responded to the EPA's comments and indicated some of the type of information being gathered during operation of the Plant at 60% of full power.

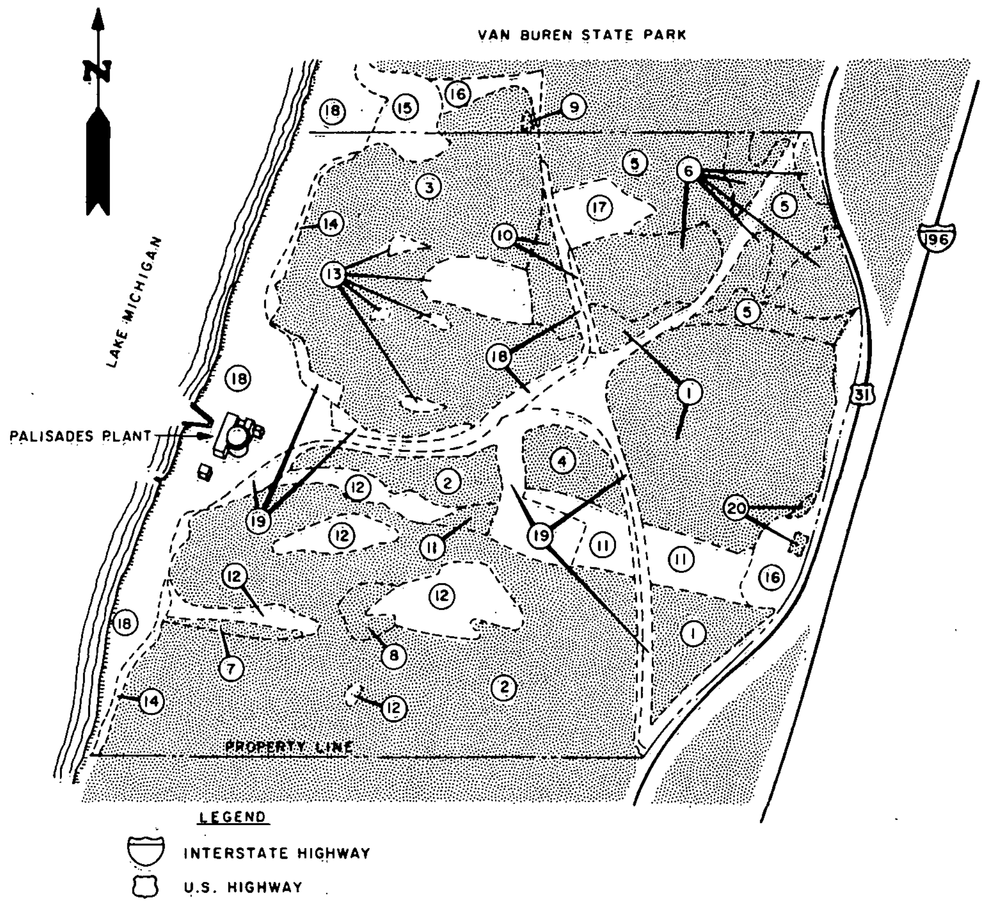
I. LOCATION OF PRINCIPAL CHANGES IN THIS STATEMENT IN RESPONSE TO COMMENTS

Topics Commented Upon	Sections Where Topics Are Addressed
Environmental Considerations in Site Selection	I.B and IV.B,C
Benefits of Not Continuing Quarrying	I.B, VIII, XI.B
Contact State Historical Officials	II.D
Runoff Water from the Site	II.E
Thermal Bar Characteristics	II.E and III.D
Right-of-Way for Transmission Lines	III.B and IV.B
Disposal of Solid Waste on Intake Screens	III.D and V.C
Section 13 Permit and Water Quality Certification	III.D
Disposal of HEPA Filters and Septic Tank Sludges	III.D
Storage and Handling of Hazardous Materials	III.D
Modification of Source Term	III.D
Use of Charcoal Adsorbers for Iodine-131	III.D and XI.A
Alternate Radwaste Modifications	III.D and XI.A
Agricultural Land Use	IV.B
Controls to Limit Construction Effects	IV.C
Enhancement of Site Area for Wildlife Habitat and Recreational Use	IV.B, V.A
Chlorine Discharges and Effects	V.C
Dilution Pattern of Thermal and Chlorine Discharges	V.C

Topics Commented Upon	Sections Where Topics Are Addressed
Heat Loading from Thermal Discharges	V.C. and VIII
Influences Affecting Fish Population	V.C
Less Productive Zone	V.C
Screening of the Crib	V.C
Ecological Monitoring Program	V.C
Recalculated Cumulative Population Dose	V.D
Bioaccumulation Factors	V.E
Cold Shock on Fish	V.C and App. V-2
Thermal Effects on Fish	V.C and App. V-2
Information on Lake Trout, Perch	V.C and App. V-2
Environmental Costs of Cooling Systems	V.C and XI.B
Updated Need for Power Information	X
Long-Term Power Growth	VIII and X
Identification of Plant Benefits	XI.B
Number of Visitors Per Year	XI.B

APPENDIX II-1

SPECIES OF ORGANISMS IDENTIFIED IN THE VICINITY OF THE PALISADES PLANT



1. RED OAK-SUGAR MAPLE-BEECH-BLACK CHERRY
CHERRY-SASSAFRAS-OAK-MAPLE-HOP HORNBEAM-WITCH HAZEL-HEMLOCK
SASSAFRAS-OAK-MAPLE-VIBURNUM-GREENBRIER-FORBS
2. RED OAK-SUGAR MAPLE-BEECH-BASSWOOD-ASH-CHERRY-HOP HORNBEAM
SASSAFRAS-MAPLE-OAK-HOP HORNBEAM-WITCH HAZEL-HEMLOCK-PINE-CHOKE CHERRY
OAK-MAPLE-SASSAFRAS-GREENBRIER-VIBURNUM-GRAPE-FERN-FORBS
3. RED OAK-SUGAR MAPLE-BLACK CHERRY-BEECH-BASSWOOD-WHITE OAK
SASSAFRAS-OAK-MAPLE-HOP HORNBEAM-WITCH HAZEL-CHOKE CHERRY-HEMLOCK-BEECH
SASSAFRAS-OAK-MAPLE-WITCH HAZEL-GREENBRIER-VIBURNUM-GRAPE-FERN-FORBS
4. BLACK GUM-RED, WHITE OAK-MAPLE
BLACK GUM-OAK-PINE-ASPEN
OAK-SASSAFRAS-GREENBRIER-SPIRAEA-FERN-FORBS
5. RED, WHITE OAK-CHERRY-WHITE PINE-ASPEN-SASSAFRAS
OAK-SASSAFRAS-BLACKBERRY-HOPTREE
ASPEN-GREENBRIER-FERN-BEACH GRASS-FORBS
6. OAK-RED, WHITE, JACK PINE-ASPEN-ASH-CHERRY
OAK-CHERRY-GREENBRIER-FORBS
7. WHITE PINE-RED OAK
HOP HORNBEAM-PINE-OAK-MAPLE-HEMLOCK
HEMLOCK-PINE-YEW-VIBURNUM-GREENBRIER-OAK
8. WHITE PINE-RED OAK
OAK-CHERRY-MAPLE-SASSAFRAS-HOP HORNBEAM-FORBS
9. RED PINE
10. RED OAK-SASSAFRAS-BLACK GUM
ASPEN-ASH-WILLOW-SASSAFRAS
GRASS-FORBS-SPIRAEA
11. BASSWOOD-SASSAFRAS-OAK-RED MAPLE-BLACKBERRY
SASSAFRAS-BEACH GRASS-FORBS-FERN-GRAPE
12. SASSAFRAS-OAK-PINE-DOGWOOD-SAND CHERRY
BEACH GRASS-FORBS-FERN-BARE SAND
13. OAK-SASSAFRAS-SAND CHERRY
BEACH GRASS-GRAPE-FORBS-BARE SAND
14. COTTONWOOD-RED OAK-WHITE PINE-BASSWOOD
BEACH GRASS-FORBS
15. BEACH GRASS-GRAPE-FORBS
16. BEACH GRASS-FORBS
17. FORBS
18. BARE SAND-FORBS
19. BEACH GRASS
20. CATTAILS-GRASS-FORBS

APPENDIX II-1
Fig. 1
ECOLOGICAL SURVEY
PALISADES PLANT

APPENDIX II-1 TABLE I

SPECIES LIST OF WILDLIFE ON THE PALISADES PLANT SITE AT VARIOUS TIMES THROUGH THE YEAR, AND AN ESTIMATE OF THEIR POPULATIONS BASED ON DIRECT OBSERVATION, OBSERVATION OF ANIMAL SIGNS (TRACKS, SCATS, NESTS, DEN SITES, ETC.), AND INFORMATION FROM INDIVIDUALS IN THE REGION (REF. 1).

WILDLIFE SPECIES	ESTIMATED POPULATION (Rare, Common, Abundant)
Upland Game Birds	
Ruffed Grouse (Bonasa umbellus)	Common-Abundant
Mourning Dove (Zenaidura macroura)	Abundant
Woodcock (Philohela minor)	Common
Ringneck Pheasant (Phasianus colchicus)	Rare-Common
Bobwhite Quail (Colinus virginianus)	Rare
Fur and Game Mammals	
Opossum (Didelphis virginiana)	Common
Striped Skunk (Mephitis mephitis)	Common
Woodchuck (Marmota marmota)	Rare-Common
Eastern Cottontail (Sylvilagus floridanus)	Abundant
Raccoon (Procyon lotor)	Common
Fox Squirrel (Sciurus niger)	Common-Abundant
Gray Squirrel (Sciurus carolinensis)	Rare-Common
Red Squirrel (Tamiasciurus hudsonicus)	Common
Red Fox (Vulpes fulva)	Common
Weasel (Mustela sp.)	Rare
Mink (Mustela vision)	Rare
Small Mammals	
Eastern Chipmunk (Tamias striatus)	Abundant
Ground Squirrel (Citellus tridecemlineatus)	Common
Common Mole (Scalopus aquaticus)	Common
Starnose Mole (Condylura crista)	Common
Hoofed Browsers	
White-tailed Deer (Odocoileus virginianus)	Abundant
Waterbirds (Sandy Beach Habitat)	
Herring Gull (Larus argentatus)	Common
Ring-billed Gull (Larus delawarensis)	Common
Common Tern (Sterna hirundo)	Common

Birds of Prey

Red-tailed Hawk (Buteo jamaicensis)	Common
Bald Eagle (Haliocetus leucocephalus)	Rare
Golden Eagle (Aquila chrysaetos)	Rare
Osprey (Pandion haliaetus carolinensis)	Rare
Sparrow Hawk (Falco sparverius)	Common
Screech Owl (Otus asio)	Common

Songbirds and Other Birds

Killdeer
Whippoorwill
Nighthawk
Ruby-throated Hummingbird
Yellow-shafted Flicker
Redheaded Woodpecker
Hairy Woodpecker

Downy Woodpecker
Eastern Kingbird
Crested Flycatcher
Least Flycatcher
Wood Pewee
Tree Swallow

Bluejay
Crow

Black-capped Chickadee
Tufted Titmouse
White-breasted Nuthatch
Red-breasted Nuthatch
Brown Creeper
House Wren
Scarlet Tanager
Rose-breasted Grosbeak
American Goldfinch
Vesper Sparrow
Swamp Sparrow

Catbird
Brown Thrasher
Robin
Wood Thrush
Hermit Thrush
Bluebird
Golden-crowned Kinglet
Ruby-crowned Kinglet
Cedar Waxwing
Starling
Warbling Vireo
Yellow Warbler
Black-throated Blue Warbler
Myrtle Warbler
Black-throated Green Warbler
Yellowthroat
House Sparrow
Meadowlark
Red-winged Blackbird
Baltimore Oriole
Common Grackle
Cardinal
Indigo Bunting
Fufous-sided Towhee
Field Sparrow
Song Sparrow

NOTE: Additional species of wildlife may also be present.

APPENDIX II-1 TABLE 2a

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE AREA OF THE COOK PLANT, BENTON HARBOR, MICHIGAN, ON AUGUST 11, 1969 (REF. 2).

Organism	Number of Colonies	Cells/liter
Schroederia judayi		2,781
Peridinium sp.		66,744
Cryptomonas sp.		30,591
Chlamydomonas sp.		15,759
Oocystis sp.		26,883
Oocystis solitaria		8,343
Cyclotella sp.		305,910
Oscillatoria sp.		16,686
Mougeotia sp.		70,542
Anabaena sp.		7,416
Actinastrum hantzschii		65,817
Golenkinia radiata		1,854
Dinobryon divergens		9,270
Gloeocystis sp.		12,051
Cosmarium sp.		2,781
Closterium sp.		2,781
Ankistrodesmus falcatus		36,153
Ulothrix sp.		2,781
Pediastrum sp.		1,854
Treubaria setigerum		2,781
Quadrigula lacustris		927
Tetraedron minimum		927
Lagerheimia longiseta		2,781
Scenedesmus bijuga		1,854
Scenedesmus opoliensis		11,124
Scenedesmus quadricauda		2,781
Scenedesmus incrassatulus		7,416
Kirchneriella obesa		1,854
Nephrocytium		927
Synedra ulna		9,270
Synedra sp.		1,854
Synedra delicatissima		5,562
Crucigenia apiculata	927	3,708
Melosira granulata	12,051	61,182

Organism	Number of Colonies	Cells/liter
Tabellaria fenestrata	5,562	18,540
Melosira granulata, v. angustissima	15,579	53,766
Dictyosphaerium pulchellum		2,781
Melosira binderana	927	6,489
Melosira sp. 1	927	7,416
Synedra acus		927
Tetraedron lunula		927
Aphanizomenon flos-aquea		927
Tetrastrum sp.		1,854
Fragilaria crotonensis	1,854	12,051

APPENDIX II-1 TABLE 2b

PHYTOPLANKTON COLLECTED ONE MILE OFFSHORE FROM THE COOK PLANT, BENTON HARBOR, MICHIGAN, AT 15 m DEPTH (REF. 2). OCTOBER 4, 1969.

Organism	Number of Colonies	Cells/liter
Chroococcus colonies	3,708	
Anabaena sp.		1,854
Chlamydomonas spp.		92,700
Flagellates		128,853
Cyclotella spp.		893,628
Dinobryon sp.		13,905
Asterionella formosa	3,708	36,153
Oocystis sp.		36,153
Scenedesmus sp.		32,445
Tabellaria fenestrata	8,343	35,153
Dictyosphaerium pulchellum		9,270
Tetraedron sp.		2,781
Melosira binderana	1,854	10,197
Melosira granulata	135,342	704,520
Gomphosphaeria sp.		7,416
Coelastrum sp.		12,978
Cosmarium sp.		4,635
Closterium sp.		927
Aphanocapsa sp.		15,759
Lagerheimia sp.		5,562
Ankistrodesmus falcatus		19,467
Stephanodiscus niagarae		927
Navicula sp.		927
Crucigenia sp.		927
Nitzschia sp.		3,708
Synedra sp.		4,635
Pediastrum sp.		927
Fragilaria crotonensis	2,781	20,394

APPENDIX II-1 TABLE 2b

6 June 1970

Organism	Number of Colonies	Cells/liter
Closterium sp.		3,708
Ankistrodesmus falcatus		16,686
Fragilaria crotenesis		62,109
Achnanthes sp.		2,781
Dinobryon divergens		9,270
Synedra ulna		4,635
Synedra ulna v. damica		21,321
Cymatopleura solea		927
Synedra ostenfeldii		7,416
Phormidium sp.		5,562
Fragilaria intermedia		18,540
Melosira islandica	3,700	34,299
Melosira granulata		18,540
Synedra filiformis		8,343
Peridinium sp.		1,854
Nitzschia spp.		62,109
Oscillatoria sp.		8,343
Tabellaria flocculosa		3,708
Dinoflagellates		1,854
Cyclotella spp.		247,509
Tabellaria fenestrata		242,874
Chlamydomonas spp.		94,554
Cryptomonas spp.		27,810
Amphora ovalis		927
Gomphonema sp.		927
Synedra v. chaseana		1,854
Fragilaria capucina		18,540

APPENDIX II-1 TABLE 2b

26 April 1970

Organism	Cells/liter
Cyclotella sp.	241,150
Chlamydomonas spp.	252,280
Tabellaria fenestrata	121,705
Fragilaria crotonensis	14,840
Ankistrodesmus falcatus	63,070
Mallomonas spp.	38,955
Peridinium	22,260
Dinobryon divergens	31,535
Synedra filiformis	1,855
Quadrigula chodatii	1,855
Synedra ulna	12,985
Phomidium sp.	9,275
Melosira granulata	25,970
Cryptomonas spp.	18,550
Fragilaria intermedia	27,825
Nitzschia sp.	7,420
Melosira binderana	152,110
Melosira islandica	371,000

APPENDIX II-1 TABLE 3

SEASONAL ABUNDANCE OF PLANKTONIC ALGAE IN LAKE MICHIGAN NEAR THE COOK PLANT (REF. 2).

Month & Year	Organisms	No. of species	Cells per liter
		SPRING	
April 1970	Diatoms	10	987,000
	Green algae	2	65,000
	Flagellates	5	364,000
	Blue-greens	1	9,000
May 1970	Diatoms	21	3,120,000
	Green algae	9	250,000
	Flagellates	5	544,000
	Blue-greens	2	30,000
		SUMMER	
June 1970	Diatoms	18	757,000
	Green algae	2	20,000
	Flagellates	5	135,000
	Blue-greens	2	14,000
August 1969	Diatoms	11	483,000
	Green algae	26	274,000
	Flagellates	4	122,000
	Blue-greens	3	25,000
		FALL	
October 1969	Diatoms	10	1,711,000
	Green algae	11	126,000
	Flagellates	3	235,000
	Blue-greens	4	29,000

APPENDIX II-1 TABLE 4

SPECIES LIST OF BENTHIC MACROINVERTEBRATES COLLECTED IN LAKE MICHIGAN OF THE PALISADES PLANT (REF. 3).

<u>DIPTERA</u>

*F. Chironomidae
*SF. Chironominae
Chironomus sp.
C. riparius
C. staegeri
C. (Dictrotendipes)
C. tendipediformes
C. decorus
Cryptochironomus sp.
C. nais
C. blarina
Polypedilum sp.
Polypedilum fallax
Micropsectra sp.
Paralauterborniella sp.

SF. Diamesinae
Diamesa longimanus
Prodiamesa bathyphila

SF. Orthocladiinae
Nanocladius sp.
Psectrocladius sp.

SF. Tanypodinae
Procladius culiciformes

<u>OLIGOCHAETA</u>

Tubificidae
Limnodrilus claparedeianus
L. hoffmeisteri
L. angustipenis
L. profundicola
Peloscolex ferox
Tubifex tubifex
Tubificidae sp. (indet.)

<u>MOLLUSCA</u>

Pelocypoda
Pisidium aequilaterale
P. casertanum
P. fallax
P. henslowanum
P. insigne
P. nitidum
P. obtusale
P. ferrugineum
P. subtruncatum
P. variabile
Sphaerium nitidum
S. striatinum
S. sulcatum
S. transversum

Sphaerium rhomboideum
Sphaerium fabale
S. partumeium

Gastropoda
Amnicola sp.
Parapholyx sp.

Gyraulus sp.
Lymnaea sp.
Valvata sp.
Physa sp.

<u>HIRUDINEA</u>

Glossiphoniidae

<u>COELENTERATA</u>

<u>TURBELLAREA</u>

"F" is family name, and "SF" is subfamily name.

OLIGOCHAETA (Cont'd)

Potamothrix moldaviensis
Naididae
Stylaria lacustris
Uncinais uncinata
Lumbriculidae
Stylodrilus heringianus

CRUSTACEA
Amphipoda
Pontoporeia affinis
Decapoda
Mysis relicta
Mysis sp.
Copepoda
Cyclops sp.

APPENDIX II-1 TABLE 5

SPECIES LIST OF LAKE MICHIGAN ZOOPLANKTON COMPILED FROM INCOMPLETE ANALYSES OF SAMPLES FROM THE COOK POWER PLANT SITE (30 MILES SOUTH OF PALISADES) AND FROM OPEN LAKE STUDIES OFF FRANKFORT AND GRAND HAVEN, MICHIGAN (REF. 4).

	Cook Site	Open Lake
Cladocerans	Bosmina spp.	Daphnia galeata mendotae Birge
	Daphnia spp.	Daphnia retrocurva Forbes
	Polyphemus spp.	Bosmina longirostris (O. F. Muller)
	Alona spp.	Diaphanosoma brachyurum (Lieven)
	Leptodera spp.	Holopedium gibberum Zaddach
	Holopedium spp.	Sida cyrstallina (O. F. Muller)
	Ceriodaphnia spp.	Leptodora kindti (Focke)
	Diaphanosoma spp.	Polyphemus pediculus (L.)
Copepods	Diaptomus spp.	Cyclops bicuspidatus Claus
	Senecella spp.	Mesocyclops edax (Forbes)
	Epischura spp.	Diaptomus minutus Lilljeborg
	Eurytemora spp.	Diaptomus ashlandi Marsh
	Limnocalanus spp.	Diaptomus sicilis Forbes
	Unidentified Cydopoids	Diaptomus oregonensis Lilljeborg
		Epischura lacustris Forbes
		Limnocalanus macrurus Sars
Rotifers	Asplanchna spp.	Senecella calanoides Juday

APPENDIX II-1 TABLE 6

SPECIES LIST OF FISH COLLECTED IN LAKE MICHIGAN BY SEINING, GILL NETTING AND TRAWLING NEAR THE PALISADES PLANT (REF. 5)

Common Name	Scientific Name
Alewife	Alosa pseudoharengus
Lake whitefish	Coregonus clupeaformis
Cisco (Lake herring)	Coregonus artedii
Bloater	Coregonus hoyi
Yellow perch	Perca flavescens
Smelt	Osmerus mordax
Longnose dace	Rhinichthys cataractae
Trout-perch	Percopsis omiscomaycus
Spottail shiner	Notropis hudsonius
Lake trout	Salvelinus namaycush
Coho salmon	Oncorhynchus kisutch
Chinook salmon	Onchorhynchus tshawytscha
Longnose sucker	Catostomus catostomus
White sucker	Catostomus commersoni
Golden redhorse	Moxostoma erythrurum
Channel catfish	Ictalurus punctatus
Northern pike	Esox lucius
Round whitefish	Prosopium cylindraceum
Johnny darter	Etheostoma nigrum
Emerald shiner	Notropis atherinoides
Bluegill	Lepomis macrochirus
Mottled sculpin	Cottus bairdi
Common shiner	Notropis cornutus
Burbot	Lota lota
Black bullhead	Ictalurus melas
Carp	Cyprinus carpio
Quillback	Carpiodes cyprinus
Smallmouth bass	Micropterus dolomieui

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APPENDIX III-I

CHEMISTRY OF CHLORINE IN FRESHWATER

A summary of the chemistry of chlorine in freshwater is presented as an appendix to the Palisades Environmental Impact Statement because chlorine appears to provide one of the principal impacts of the once-through cooling system that is to be employed initially. To appreciate the potential impacts, one must become reasonably familiar with a concise terminology and some applied chemistry.

Much progress was made in the 1940's in the use of chlorine for the sterilization of water supplies. Griffin[1] gave an annotated guide to over a hundred papers published between 1939-1952. Fair[2] gave a lucid exposition of the behavior of chlorine as it was then understood. The subject has been summarized recently by Lewis.[3]

Certain terms have come into use to describe chlorine in water. They are often used carelessly in industrial practice. The distinctions given are those of Lewis.[3]

a) Free Chlorine: (Short for Free Available Chlorine).

That part of the chlorine injected into the water that remains as molecular chlorine, hypochlorous acid, and hypochlorite ion.

b) Combined Chlorine: (Short for Combined Available Chlorine).

That part of the chlorine injected into the water that remains combined with ammonia or other nitrogenous compounds.

c) Active Chlorine: (Alternative for Total Available Chlorine or Chlorine Residual.)

The total free and/or combined chlorine that remains. The terms "active" and "available" refer by implication to activity and availability for sterilization. The amount of "active chlorine" present is recognized as being equivalent to the amount of iodine that will be released from potassium iodide at acid pH.

d) Chlorine Demand:

By implication, the exact amount of chlorine required to oxidize completely all compounds that reduce free chlorine in the water.

In practice, the term is used when referring to the difference between the dose and the active chlorine left (chlorine residual) after a particular period of contact, for one particular dose rate.

Reactions During Chlorination

As soon as chlorine dissolves in water it hydrolyzes:

$$Cl_2 + H_2O \rightleftarrows HClO + H^+ + Cl^-.$$

This hydrolysis is virtually complete, and only when the pH is below 3.0, or if the chlorine concentration is of the order of 1,000 ppm, is there any measurable quantity of measurable chlorine. Further, this hydrolysis is complete within seconds at ordinary temperatures. The full oxidizing capacity of the chlorine is retained in the hydrolysis product, HClO, although one chlorine atom from each molecule has been transformed to a chloride ion. The hypochlorous acid then ionizes:

$$HClO \rightleftarrows H^+ + ClO^-.$$

At pH 7.0 the equilibrium is approximately 75% HClO, and 25% ClO^-, and at pH 8.0 this is reversed to approximately 25% HClO, and 75% ClO^- (at a water temperature of 20°C).

When hypochlorite salts such as sodium hypochlorite are dissolved in water, hypochlorite ion will form first, followed by hypochlorous acid:

$$NaClO \rightleftarrows Na^+ + ClO^- , \text{ and } H^+ + ClO^- \rightleftarrows HClO.$$

There are apparent differences in disinfecting properties of chlorine gas and hypochlorite solutions, which Fair et al.[2] considered were caused by failure of the experimenter to adjust the pH, or other experimental errors. Injection of chlorine gas will lower the initial pH, whereas addition of hypochlorite solution will raise the pH.

When ammonia or organic amines are present in the water they react with hypochlorous acid to give chloramines which are highly toxic to aquatic life. The first step is the formation of monochloramine:

$$NH_3 + HClO \rightleftarrows NH_2Cl + H_2O.$$

The rate of reaction between ammonia and hypochlorous acid is dependent on pH, and is maximum at pH 8.3. Fair et al.[2] found that for a mixture of 0.8 ppm chlorine and 0.32 ppm ammonia-nitrogen, at 25°C, 99% of the chlorine reacted in 1 minute at pH 8.3, in 210 minutes at pH 5.0, and in 50 minutes at pH 11.0. The rate of reaction varied with temperature (Q10 values ranging from 2.0 to 2.5 according to pH).

The next step is the formation of dichloramine from monochloramine and hypochlorous acid:

$$NH_2Cl + HClO \rightleftarrows NHCl_2 + H_2O,$$

the dichloramine being in equilibrium with monochloramine:

$$2NH_2Cl + H^+ \rightleftarrows NH_4^+ + NHCl_2.$$

This equilibrium depends upon both pH and the ratio of chlorine to ammonia. Fair et al.[2] found that with a chlorine to ammonia-nitrogen ratio of 5:1, the relative percentage of the two chloramines were:

> at pH 5.0, 16% monochloramine and 84% dichloramine; and at pH 8.0, 85% monochloramine and 15% dichloramine.

The third step in the chloramine formation is generalized as:

$$NHCl_2 + HClO \rightleftarrows NCl_3 + H_2O,$$

but it is evident from disagreements in the literature that little is known about the reactions at this stage. As more chlorine is added in excess of that required for the above reactions the chloramines break down, with an overall reaction:

$$3Cl_2 + 2NH_3 \rightleftarrows N_2 + 6Cl^- + 6H^+,$$

giving a chlorine to ammonia-nitrogen ratio of 7.6:1.

Theoretically, with a chlorine to ammonia-nitrogen ratio of 7.6:1, the reaction should be complete, so that no residual chlorine remains. This is known as the breakpoint. With a higher percentage of chlorine the excess should remain as free chlorine, and with a lower percentage of chlorine, the chlorine should consist of a mixture of mono- and dichloramines.

In practice, when waters containing organic amines, as well as ammonia, are chlorinated, such a clearcut breakpoint is not obtained.

Pulham[4] gave some "illustrative" breakpoint curves for these conditions. These curves show that where organic amines are present it is possible for chloramines and free chlorine to coexist. This is shown diagrammatically in Appendix III-1, Fig. 1. Presumably, where free chlorine coexists with combined chlorine, all mono- and dichloramine must have been oxidized, and the remaining combined chlorine must be organic chloramine.

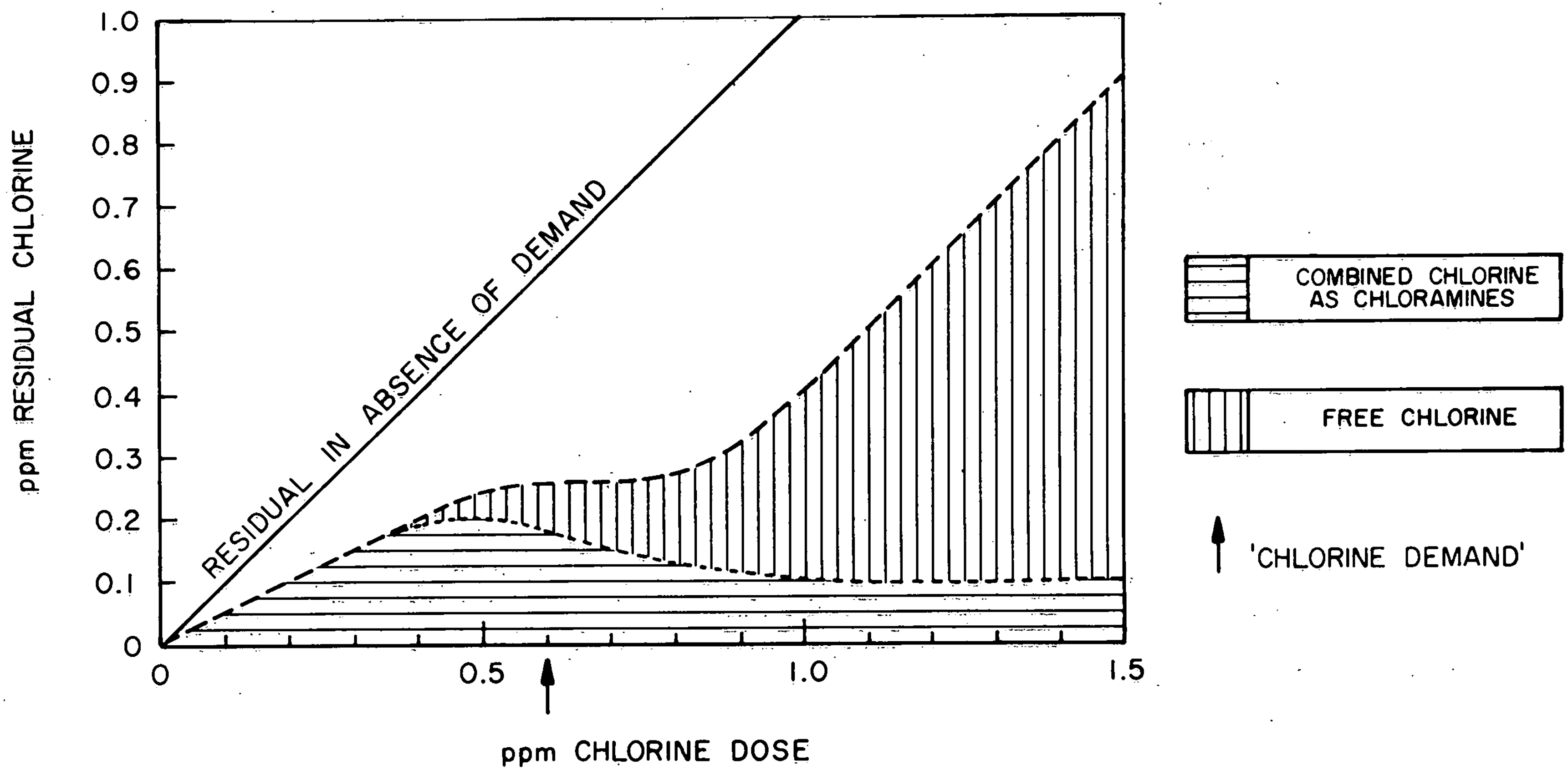
Ingols et al.[5] studied reactions between chlorine and amino acids (at concentrations of 10^{-4} M amino acid). HClO would oxidize sulfhydryl groups to sulfonic groups and then deaminate the amino acid through the formation of chloramines. With slightly more monochloramine an organic chloramine formed that was stable for some hours. With monochloramine the sulfhydryl groups were oxidized to give disulfide linkages.

Analyzing for Chlorine Residuals

Several evaluations have been made of the numerous analytical methods used for determining residual chlorine in water. Nicolson,[6] who evaluated 9 colorimetric and 3 titrimetric methods found that the barbituric acid method was the best laboratory colorimetric procedure if combined chlorine residual was absent. In the presence of combined chlorine, the N-diethyl-p-phenylenediamine (DPD) method was more satisfactory. Lishka et al.,[7] who analyzed the results from 72 participating laboratories using several different analytical methods, reported that the ferrous-DPD method had the best accuracy and precision, followed closely by the methyl orange, SNORT (Stabilized Neutral Orthotolidine), and amperometric methods. None of the methods has outstanding reliability even when care is taken (See Appendix III-1, Table 1). Reliability is undoubtedly even less in truly routine analyses.

The Standard Methods for the Examination of Water and Wastewater[8]

The ferrous-DPD, the orthotolidine-arsenite, the leuco crystal violet, the methyl orange, and the SNORT methods all determined both free and combined chlorine residuals. However, the determination of combined residual is dependent upon monochloramine and dichloramine, and the extent of their influence depends upon the types of organic compounds present.



APPENDIX III-1
Fig. 1

Typical Pattern of Chlorine Reaction With Natural Water.(3) Actual Scale Values Are Dependent Upon Local Conditions.

APPENDIX III-1 TABLE 1

PRECISION AND ACCURACY DATA FOR RESIDUAL CHLORINE METHODS BASED UPON DETERMINATION BY SEVERAL LABORATORIES[8].

Method	Residual Chlorine Concentration		Number of Laboratories	Relative Standard Deviation (%)	Relative Error (%)
	Free µg/liter	Total µg/liter			
Iodometric		840	32	27.0	23.6
		640	30	32.4	18.5
		1,830	32	23.6	16.7
Amperometric	800		23	42.3	25.0
		640	24	24.8	8.5
		1,830	24	12.5	8.8
Orthotolidine	800		15	64.6	42.5
		640	17	37.3	20.2
		1,830	18	31.9	41.4
Orthotolidine-arsenite	800		20	52.4	42.3
		640	21	28.0	14.2
		1,830	23	35.0	49.6
Stabilized neutral orthotolidine	800		15	34.7	12.8
		640	16	8.0	2.0
		1,830	17	26.1	12.4
Ferrous DPD	800		19	39.8	19.8
		640	19	19.2	8.1
		1,830	19	9.4	4.3
Leuco crystal violet	800		17	32.7	7.1
		640	17	34.4	0.9
		1,830	18	32.4	18.6
Methyl orange	800		26	43.0	22.0
		640	26	30.1	14.2
		1,830	26	19.9	7.2

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APPENDIX V-1

COOLING TOWER CHEMICALS--POTENTIAL ENVIRONMENTAL DEGRADATION*

Introduction

Cooling towers dissipate heat directly into the atmosphere without first utilizing a reservoir or heat sink as in once-through cooling. The main justification for the towers, as at Palisades, has been concern for the environmental effects of once-through cooling on aquatic life. However, cooling towers, too, have the potential for environmental damage that should be carefully studied prior to their widespread installation and use. The principal impact to be studied is long-range metorological changes caused by large amounts of heat and water vapor added to the atmosphere from the towers. Other environmental impacts, most notably dispersion of the chemical discharges of the blowdown and drift from cooling towers, have been little studied.

Wet cooling towers require large amounts of chemicals in the recirculating water to prevent corrosion and to inhibit biological attack. Because large amounts of water evaporate, salt concentrations build up in the remaining tower water, and some of this--the blowdown--must be bled off and discharged. In addition to losses from blowdown and evaporation, there is drift (droplets of water that escape from the tower stacks along with the vapor plume) that contains chemicals in the same concentration as in the recirculating water and blowdown. Thus, chemicals added to tower water can find their way directly into surrounding aquatic or terrestrial ecosystems through blowdown and drift.

Although untreated blowdown is undoubtedly the major source of environmental problems connected with cooling towers (its quantity and content of chemicals are easily determined), drift is too often considered negligible. Depending upon tower design and drift eliminators, calculated drifts vary from 0.01% to 0.3% of the recirculating water rate, the losses usually being higher for small towers. Drift from large natural draft cooling tower serving a 2,500 megawatt power plant has been calculated to be 4 tons of solids per day, assuming makeup water with 200 ppm of total dissolved solids (TDS) and drift of 0.2% of the recirculation rate. Most of the solids would be calcium and magnesium salts occurring naturally in the makeup water, and the rest would be chemicals added to the tower water.

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* **Draft manuscript**, by S. H. Hale, R. S. Carlsmith, and C. C. Coutant, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Relative volumes of blowdown to the aquatic environment and drift to the terrestrial environments have been calculated for smaller towers. Drift is 30% to 45% of the water loss, so that treatment of the blowdown alone removes only 55% to 70% of the chemical pollution. In order to further reduce the chemical effluents from cooling towers, drift eliminators must be used.

COMPOSITIONS AND CONCENTRATIONS OF COOLING TOWER CHEMICALS

Corrosion and Scale Inhibitors

Commonly used corrosion inhibitors for open recirculating systems include various mixtures of zinc, chromate, phosphate (organic or inorganic), sodium silicate, nitrate, borate, and organic inhibitors. To prevent scale deposition and to provide effects, organic phosphate compounds such as aminimethylenephosphonate are used in concentrations up to 3 ppm. Mr. R. J. Cunningham, Calgon Corporation, listed the following corrosion and scale-inhibiting chemicals (with their concentrations) in an open letter to Mr. Frank Rainwater of the Environmental Protection Agency:[3]

1.	Chromate plus zinc	5 to 30 mg/liter* CrO_4 1 to 15 mg/1 Zn
2.	Chromate plus zinc plus phosphate	5 to 30 mg/1 CrO_4 1 to 15 mg/1 Zn 1 to 5 mg/1 PO_4 (inorganic) 1 to 5 mg/1 PO_4 (organic)
3.	Zinc plus inorganic phosphate	10 to 30 mg/1 PO_4 2 to 10 mg/1 Zn
4.	Zinc plus organic phosphate	1 to 10 mg/1 Zn 3 to 15 mg/1 PO_4 (organic)
5.	Organic phosphate scale inhibitor	1 to 18 mg/1 PO_4 (organic)
6.	Specific copper corrosion inhibitors	1 to 5 mg/1 sodium mercaptobenzothiazle or benzotriazole

* 1 mg/liter = 1 ppm

As seen in numbers 1 and 2 above, chromate, zinc, and phosphate are often used together because of the synergistic anticorrosive effects produced when they are combined.

Biocides

Of the commonly used biocides, chlorine or hypochlorite (as planned at Palisades) or nonoxidizing organic compounds such as chlorophenols, quaternary amines, and organo-metallics such as organotin compounds, organosulfur, and organothiocyanate (Table 1) are most frequently employed. They are all used to prevent deterioration of tower wood, loss of heat transfer efficiency, general fouling or plugging arising from microbial growths, and corrosion that results from microbial attack.[(2)] Organo-tin must be formulated with quaternary ammonium and other complex amines to produce a synergistic effect and to be dispersible. Chlorophenols, as soluble potassium and sodium salts, are more peristent than free chlorine and remain in systems longer. Common chlorophenols include: 2,4,5-trichlorophenate; 2,4,6-T; 2,3,4,6-T; tetrachlorophenol; and pentachlorophenol. Organosulfurs are noted for low toxicity to animals, yet effective action against bacteria, fungi, and especially sulfate-reducing bacteria. Quarternary and complex amines are effective wetting agents and destroy microbial agents by surface-active properties; these are the least toxic of all antimicrobial compounds to animals, although they may form and so cause aesthetic problems. The organothiocynates, the most modern of the nonoxidizing biocides, are widely effective. Oils, organic chemicals, water hardness, and other materials seem to cause little reduction in their effectiveness, especially if they are combined with chlorophenols. The nonoxidizing biocides are used whenever the problems are rather severe and where the use of free chlorine is not acceptable. Typical concentrations for continuous use are 1 to 25 ppm; higher (200 ppm or so) if applied in periodic treatments. Elemental chlorine is an oxidizing agent and can cause rapid deterioration of wood. The use of free chlorine as a biocide is usually restricted to 1.0 ppm as free residual Cl_2 and to 1 to 2 hours per day.[3]

The use of biocides that contain mercury, arsenic, lead, or boron is limited by stringent regulations on their release to the environment than do most of the compounds previously discussed, because of their extreme toxicity.[4] These are rarely if ever used now; however, a review of label names in Table 1 reveals that the potentially toxic materials, copper and thiocyanate ions, are present in some commercial compounds. Tin is probably also questionable as far as toxicity is concerned. All of the chemical labels note that precautions should be used in handling of the product, and two indicate that the product may be harmful or fatal if absorbed through the skin. Only two, however, cautioned against dumping them directly into lakes, streams, or ponds. Some of the products containing 2,4,5-T listed no such precautions; yet the compound is now expressly banned in waterways.

pH Adjustors and Silt Control (Antifoulant) Polymers

Scale and corrosion inhibitors and biocides require the addition of acid or alkali to makeup water to keep the pH at an optimum level, usually a range from 5.5 to 7.5. Silt controls polymers may be used if makeup is raw water from a nearby lake or river. Lignin-tannin dispersives such as 1 to 50 ppm sodium lignosulfonate may be employed. Antifoulants such as 0.1 to 5 ppm of acrylamids, polyacrylate, polyethyleneimine, or other high molecular synthetic organic polyelectrolytes may also be used.[3]

Table 1. CHEMICAL COMPOSITION OF TRADE NAME MICROORGANISM CONTROL CHEMICALS

(From company sources and Environmental Protection Agency)

	COMPOSITION (%)	USAGE
NALCO 21-S		
		periodically,
Sodium pentachlorophenate	21.3	as needed
Sodium 2,4,5-trichlorophenate	11.9	25-400 ppm
Sodium salts of other Chlorophenols	3.0	or
Inert ingredients	63.8	continuously
NALCO 25-L or NALCO 425-L		weekly
1-Alkyl (C_6 to C_{18})-amino-3-aminopropane propionate-copper acetate complexes	15.0	20-300 ppm
Isopropanol	30.0	
Copper sulfate expressed as metallic copper	0.55	
Inert ingredients	55.0	
NALCO 201		
		periodically,
Potassium pentachlorophenate	15.7	as needed

	COMPOSITION (%)	USAGE
Potassium 2,4,5-trichlorophenate	9.0	300-400 ppm
Potassium salts of other chlorophenols	1.8	or
Inert ingredients	70.3	12-60 ppm continuously
NALCO 202		
		5-200 ppm periodically
Methyl-1, 2-dibromopropionate	29.7	or
Inert ingredients	70.3	continously
NALCO 207		weekly
Methylene bisthiocyanate	10.0	25-50 ppm
Inert ingredients	90.0	
NALCO 209		
		as needed
1.3-Dichloro-5, 5 dimethyl hydantoin	25.0	50-100 ppm
Inert ingredients	75.5	
NALCO 321		
1-Alkyl (C_6 to C_{18})* amino-3-aminopropane		weekly
monoacetate	20.0	5-200 ppm
Isopropanol	30.0	
Inert ingredients	50.0	
* As in fatty acids of coconut oil		
NALCO 322		
1-Alkyl (C_6 to C_{18})* amino-3-aminopropane		as needed
monoacetate	19.8	10-200 ppm
2,4,5-Trichlorophenol	9.5	
Isopropanol	27.0	
Inert ingredients	43.7	
* As in fatty acids of coconut oil		
NALCO 405		
		as needed
2, 4-Dinitrochlorobenzene	22.2	100-200 ppm
2, 6-Dinitrochlorobenzene	2.8	
Inert ingredients	75.0	

	COMPOSITION (%)	USAGE
Betz A-9		
Sodium pentachlorophenate	24.7	
Sodium 2, 4, 5-Trichlorophenate	9.1	
Sodium salts of other chlorophenates	2.9	
Sodium dimethyl dithiocarbamate	4.0	
N-Alkyl (C_{12}-4%, C_{14}-50%, C_{16}-10% dimethyl benzyl ammonium chloride	5.0	
Inert ingredients (including solubilizing and dispersing agents)	54.3	
Betz C-5		
1, 3, Dichloro-5, 5-Dimethylhydantoin	50	
Inert ingredients (including solubilizing and dispersing agents)	50	
Betz C-30		
Bis (trichloromethyl sulfone	20.0	
Methylene disthiocyanate	5.0	
Inert ingredients (including solubilizing and dispersing agents)	75.0	
Betz C-34		
Sodium dimethyl dithiocarbamate	15.0	
Nabam (disodium ethylene bisdithiocarbamate)	15.3	
Inert ingredients (including solubilizing and dispersing agents)	69.7	
Betz J-12		
N-Alkyl (C_{12}-5%, C_{14}-60%, C_{16}-30%, C_{18}-5%) dimethyl benzyl ammonium chloride	24.0	
Bis (tributyltin) oxide	5.0	
Inert ingredients (including solubilizing and dispersing agents)	71.0	
Betz F-14		
Sodium pentachlorophenate	20.0	
2,4,5, T or Sodium 2,4,5 trichlorophenate	7.5	
Sodium salts of chlorophenate	2.5	
Dehydrobutyl ammonium phenoxide	2.0	
Inert ingredients, including dispersants	68.0	

Chemical Action

Corrosion Inhibition

Chromate ion is one of the most effective corrosion inhibitors. It is effective where it can react with iron-containing alloys to form alpha ferric oxide and chromic oxide film on the iron surface. Usually this treatment is most effective when a high concentration of chromate is circulated throughout the system until the film forms; then maintenance of a low concentration of chromate is sufficient to maintain the protective film.

Phosphate acts both as a corrosion and a scale inhibitor and may be found as sodium tripolyphosphate, sodium hexametaphosphate, and several types of "glassy" phosphates of high molecular weight. These compounds also form a protective film on metal, mostly on cathodic areas. However, at high temperature, low pH, or high calcium concentrations, the polyphosphates revert to orthophosphates, or low molecular weight or react with iron or water hardness salts to form an insoluble sludge.

Zinc ion alone is a relatively weak corrosion inhibitor but has strong synergistic qualities. It is a cathodic inhibitor that forms a deposit of zinc hydroxide on cathodic areas, thereby diminishing the cell potential.

Sodium silicate forms a thin protective gelatinous film over the first layer of corrosion product on the metal surface. High concentrations of chloride or sulfate ions may disturb the protective layer.

Organic inhibitors aid in developing protective metal oxide films by forming a protective layer of insoluble material or by creating a surface-active barrier.

Nitrite is a passivator for steel that makes the steel effectively a more noble metal. A similar passivation is provided by tin alloys; copper is a bit weaker. High concentrations of chlorides reduce the effectiveness of nitrites; for example, about 4,000 ppm of NO_2^- is required in a 3% NaCl solution, as compared with only 50 ppm in distilled water to achieve the same effect.

Borax is often included in nitrite-based inhibitors to maintain a pH of 8 to 10 in the water. It has not been demonstrated to be effective as an inhibitor.

Antifoulant Polymers[2]

Flocculants agglomerate individual particles so that they remain suspended and are easily bled off. Dispersants interfere with the agglomeration of colloidal particles that are attracted to metal surfaces, often modify their crystallization, and allow them to slough off. Chelating agents react with certain metal ions to form stable, soluble complexes; calcium, magnesium, iron, aluminum, and manganese ions may be chelated to prevent their precipitation but the reaction is stoichiometric and chelation of water hardness ions is generally uneconomical.

Toxicity

General

In Table 2 are listed some elements (present in different valent states in chemical compounds) which, historically have been used in cooling towers, along with their concentration factors by plankton and blown algae.[5] The concentration factors may signify increased toxic effects of various elements through a food chain, and suggest that even low concentrations of some contaminants in water may be harmful by the third or fourth trophic levels. Some high concentration factors, such as those exhibited by *Foraminifora* and *Porifora* for silicon, are normal. Some elements, not toxic to aquatic life, may unbalance the ecosystem by overstimulating the growth of certain plants or animals. It is well established that nitrogen and phosphorus, particularly in combination, cause massive algal blooms under conditions where these elements were previously the limiting factors. While the accumulating poisons, mercury and lead, are no longer marketed for use in cooling towers, any of the heavy metals (e.g., chromium, zinc, or tin) may cause environmental problems by remaining in sediments or by concentrating in some forms of aquatic life. Establishment of the potential threat to the environment becomes extremely difficult because the different forms and valence states of the element may vary greatly in toxicity--as with sulfur, chlorine, and mercury. Factors contributing to the change from one state to another and synergistic toxic effects must be known before cooling tower chemicals can be ranked in order of potential environmental threat.

Chromium*

Because of its widespread use and high toxicity, chromium present in different valent states in compounds merits careful attention in its

*Chromium can exist as Cr^{3+} (trivalent) or CrO_4^{2-} (hexavalent - Cr^{6+}) but concentrations are based on the weight of Cr.

Table 2. TOXICITY AND CONCENTRATION FACTORS OF ELEMENTS ONCE - OR PRESENTLY USED IN COOLING TOWERS

ELEMENT SYMBOL[a]	CONCENTRATION FACTOR** Plankton	Brown algae	FUNCTIONS	ENVIRONMENTAL TOXICITY (not injected)
*As		2,500		carcinogenic; moderately toxic to plants, highly to mammals--especially as AsH_3;
B		6.6	essential for green algea, angiosperms	moderately toxic to plants, slightly to mammals
*Br		2.8	essential for marine organisms; amino acids	Br_2 is very toxic; Br^- is relatively harmless to organisms
*Cl	1	.062	essential for mammals and angiosperms	Cl^- is relatively harmless; Cl_2, ClO^- ClO_3^- are highly toxic
*Cr	17,000	6,500	may serve some physiological function	Cr(III) is moderately toxic; Cr(VI) is highly toxic to organisms and is probably carcinogenic (by inhalation)
*Cu	17,000	920	essential to all organisms	very toxic to algae, fungi, and seed plants; highly so to invertebrates; moderately so to mammals
*Hg	-	250	---	a cumulative poison in mammals very toxic to fungi and green plants; highly to mammals in some forms
N	19,000	7,500	essential as structural atom	relatively harmless; concentrations higher in plankton and fish
*P	15,000	10,000	vital in many ways	
*Pb	41,000	70,000	none	very toxic to most plants, moderately so to mammals; cumulative poison.

*S	1.7	3.4	---	S^{2-} high to bacteria and fungi; relatively harmless to green algae, seed plants and mammals; H_2S is highly toxic to mammals; SO_3^{2-} moderately to highly; SO_4^{2-} is relatively harmless.
*Si	-	-	essential to some plants	scarcely toxic, but large amounts in mammalian lung harmful (used by Foraminifera and Porifera etc.)
*Sn	2,900	92	none	very toxic to plants and green algae
*Zn	-	-	essential to all organisms	moderately toxic to plants; slightly toxic to mammals; uptake by plant roots not linked to metabolic process.

(a) The elements listed above exist in the form of different chemical compounds with the element in different valent forms to which biota are toxic but concentrations are expressed in terms of ppm of the element not the actual compound.

* accummulator species or genera known

** ppm in fresh organism/ppm in sea water
Toxicity terms: very, 1-10 ppm; highly, 10-100 ppm; moderately, 100-1,000 ppm; slightly, over 1,000 ppm

(as 24 hr TL_m in moderate sized organisms--i.e., fish) relation to aquatic life. It is not currently being considered for use at the Palisades Plant, but it is a principal alternative should the expected effects of phosphorus (present in different chemical compounds primarily as a phosphate salt) and zinc (as the zinc ion) be deemed unacceptable. Some sources say the trivalent form shows none of the toxicity of the hexavalent form (as in the chromate ion) and is not of concern in drinking water supplies.[6] However, according to Water Quality Criteria,[7] "Most evidence points to the fact that under long-term exposure the hexavalent form is no more toxic toward fish than the trivalent form." Thus total chromium in a water supply may be much more indicative of a possible environmental problem than hexavalent chromium alone. In environments containing chromium, fish have shown that the toxicity of chromium varies with the species of fish, pH of the water, valence state of the element, and hardness of the water--the last a synergistic or antagonistic effect. Although 0.05 ppm is set as the Federal drinking water standard, Water Quality Criteria states that data are too incomplete to warrant more than caution in the discharge of chromium.

Concentrations of 0.01 and 0.02 ppm chromium in soft water have been found safe for salmonid fish, but *Daphnia* and *Microregma* show threshold effects at Cr^{6+} concentrations of 0.016 to 0.7 ppm, and 0.032-0.32 ppm inhibits growth of diatoms.[7] Oyster mortality studies at long-term (2 years) concentrations of 0.01 and 0.012 ppm showed a definite increase with an increase in temperature, so that synergistic effects may intensify the damages resulting from exposure to chromium in low concentrations.[7] Thus, even these low levels (less than drinking water standards) were found to be toxic to certain forms of plant and animal life. As concentrations of chromium increase, the ingestion-elimination balance changes and accumulation takes place. Some fish accumulate chromium when it is in concentrations as low as 1 microgram per liter or 1 part per billion.[8]

In 1958 Fromm and Schiffman published a study of the toxic action of Cr^{6+} on largemouth bass in which they determined the 48-hour median tolerance limit, TL_m, to be 195 ppm.[9] However, the focus of the study was on the physiological effects of less than acutely lethal dosages. At 94 ppm of Cr^{6+} no changes were observed in the respiratory epithelium of the fish; a slight decrease in general metabolism did occur along with widespread destruction of the intestinal epithelium. These effects differ markedly from those caused by zinc, copper, and lead, were mucus is caused to be secreted by the gills and damage to gill tissue causes eventual death.

In 1959 the same authors reported a 24-hour median tolerance limit for rainbow trout to be 100 ppm of chromium.[10] A concentration of 20 ppm of Cr^{6+} was chosen for the study of chronic physiological changes. Red blood cell concentration (hematocrit) in the circulating blood of the trout significantly increased as a result of the exposure, most probably because of an unmeasurable decrease in plasma volume. Perhaps more importantly, the hematocrit is affected at 2 to 4 ppm of chromium, a concentration much lower than the median tolerance limit and one which could easily be found in a stream receiving blowdown.

Not all fish are as tolerant of Cr^{6+} as are trout, bass, and bluegill.[11] The median tolerance limit for 24-hour exposure to potassium dichromate in soft water was 4.10 ppm (as CrO_4^{2-} for guppies, 39.6 ppm for fathead minnows, and up to 284 ppm for bluegills. In these tests, there were insignificant differences for 24, 48-, and 96-hour exposures. Trivalent chromium was found to be a toxicant; mortality rates, however, did not always increase with increasing concentration. At acutely toxic levels for fish (in the range of the medium tolerance limit), the hexavalent chromium was more toxic, but no comparisons were made of the two valence states at very low concentrations.

Water Quality Standards

Table 3 lists the Federal water quality criteria in drinking water for those chemicals used in cooling towers.[7] As yet, not all of the elements have been assigned limits; some limits were set lower for aesthetic considerations than for health considerations; for example, the low concentration limit for phenol is probably the threshold for taste in water.

Severity of the Environmental Problem from Blowdown

The size of the environmental chemical dispersion problem, if any, connected with blowdown from a specific cooling tower depends upon: (1) the rate of blowdown, which is usually directly related to the size of the system and the number of cycles of concentration allowed by the quality of input water; (2) the choice of chemicals--a choice often dictated by the system's potential for corrosion or microbial attack, which in turn is often directly dependent on tower design and construction materials; and (3) the effectiveness of treatment of blowdown water before discharge to the environment. Drift has received less study, and the factors controlling its quantity and content are less well-known.

Table 3. RECOMMENDED UPPER LIMITS TO IONIC CONCENTRATIONS IN DRINKING WATER (Ref. 7)

Element or Compound	Upper Limit (ppm)
As	0.05
B	1.00
Br	*
Cl	250
Cr	0.05
CN	0.01
Cu	1.0
Hg	*
K	*
N (total)	10.0
NO_3	45.0
P	*
Pb	0.05
S	250
Sn	*
Zn	5.0
Phenols	0.001

* No criterion has been established.

Environmental problems can be very substantial, although immediate impact on aquatic environments may depend more upon the ratio of the stream flow rate to blowdown rate, and hence the dilution factor, than on absolute amounts. Less immediate problems, such as the dispersion of heavy metals to the environment at large, would revolve more around absolute amounts.

Reducing Impact

1. Cycles of Concentration

Pretreatment techniques can increase cycling of water in cooling towers and thus decrease system discharge. They include: (1) clarification and chemical softening of makeup water, (2) partial zeolite softening or demineralization of makeup water, (3) bypass or side-stream filtration.[3] By removing from the makeup many of the original dissolved solids which could concentrate to unacceptable levels very quickly, many more cycles of concentration--more recirculation with less blowdown-are allowed before concentrations become too high.

2. Choice of Chemicals

Heat exchanger design and tower construction materials usually determine the potential corrosion and thus determine the choice of chemicals to be added to the recirculating water. Some towers, notably natural draft towers, use no corrosion inhibitors (except acid as a pH control), while others require high concentrations of chromium, zinc and PO_4^{3-} as inhibitors. Similarly, some towers can use chlorine as a biocide, while others use a nonoxidizing biocide. TVA's cooling tower at its Paradise Steam Plant uses only acid and chlorine in the cooling water. Owing to corrosion resistant construction materials, principally concrete, and a low heat flux at the exchanger, heavy metals and phosphate are not needed in that tower for corrosion control.

3. Construction of Towers

Certain design characteristics can be adopted to avoid galvanic corrosion and reduce the need for chemical treatment.[12,13] Operational factors influencing the corrosion rate (and thus choice of inhibitor chemicals) include mineral content of the system water (which also may dictate how many times it may be recirculated), dissolved gases, electrical conductivity, suspended matter (turbidity) in the water, slime and microbial activity. More important are the design factors such as the use of corrosion resistant metals and the use of dissimilar metals of which one is expendable, a common practice throughout the industry. If the metals differ significantly in electrochemical potential, one may serve as the anode of an electrochemical corrosion cell, and the expendable metal acts as an anode and corrodes rapidly at a rate determined to some extent by the difference between the electrode potentials of the metals. If the water had good electrical conductivity, the metals need not be coupled or adjacent to corrode. The choice of metals and proper construction of the heat exchanger are extremely important, as a mistake might necessitate heavy chemical applications for the life of the tower. The primary concern may not be with rapid destruction or perforation of the tube sheet, since design specifications normally call for adequate thickness, but with the buildup of corrosion products that effectively block tubes or restrict water flow. Under certain conditions, metals that are normally cathodic can corrode, particularly where deposits form on the metal surface to set up locally different corrosion cells. Metals to be concerned with most are those that are electropositive with respect to steel, since steel adjacent to copper or copper alloys can corrode rapidly. Other unsuitable metallic pairs are copper-aluminum or steel-aluminum. However, some copper alloys such as admiralty brass and stainless steel are extremely corrosion-resistant metals if they are prevented from galvanic activity.

4. Cooling Temperatures

Temperature of the heat exchanger has a major role in determining corrosion potential. Control of scale and corrosion in the heat exchanger is more difficult at high temperature.

5. Blowdown Treatment

Most effective blowdown treatment systems have been developed for removal of chromium. Basically two methods are recognized, reduction-precipitation that discards the chromium and ion exchange that provides for chromate recovery.[14] The best known process, reduction-precipitation, is commonly used in the chromeplating industry. When carried out correctly, it removes virtually all traces of chromium from the waste stream, leaving a chromium-containing sludge for disposal. This method also is effective in removing zinc and other heavy metals, phosphate, insoluble chromic hydroxide, and all dirt and suspended solids. Some biocides may also be reduced in concentration (by 1/2 or more).[15] Ion exchange, on the other hand, while effective for removing chromate for reuse (which must be in the dichromate form), is ineffective for zinc salts or phosphate even when these are used in combination with chromates. Accessory treatment must therefore be employed for these ions. Sodium hydroxide and sodium chloride are used to regenerate the ion exchange resin, and these may be detrimental if released to natural environments.

Conclusions

All the factors--environmental, economic, engineering design, and construction--must be weighed before a tower is constructed in order that adequate environmental protection can be built in. There is very little information concerning the biocides and their fate after discharge of the blowdown and methods to render them harmless. Evidence indicates that most will not remain unchanged for long periods of time, but their very purpose in the towers attributes to their toxicity and suggests danger to aquatic ecosystems receiving blowdown. Their breakdown and dilution must be monitored after release. Tests to ascertain necessary levels of usage are required in each tower since possible overuse in current practice is indicated by the broad ranges of concentrations suggested on product labels. Corrosion tests are perhaps more common and relatively easy to do, the results indicating the concentrations of chromium that are sufficient and whether nonchromate inhibitors such as phosphate could be substituted. However, trade-offs among alternative environmental damages are involved, since phosphate encourages the growth of noxious plants. Resort to biocides less toxic to animal life (such as the organo-sulfurs or quaternary and complex amines) or those that volatalize quickly and are not released in the blowdown would reduce environmental impact, if blowdown treatments are not used. Redesigning of common industrial heat exchangers may result in use of little or no corrosion inhibitors, but some biocide will still be required.

Blowdown treatment seems to be the final determinant over what does or does not get to the environment. Increased use of chemical additives for recirculating cooling water must be matched by blowdown treatment.

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APPENDIX V-2

LIFE HISTORIES OF THE PRINCIPAL FISH SPECIES OF SOUTHEASTERN LAKE MICHIGAN IN RELATION TO POTENTIAL IMPACTS FROM THE PALISADES PLANT THERMAL DISCHARGES

Alewife (*Alosa pseudoharengus*)

The alewife, introduced via the Welland Canal between Lakes Ontario and Erie, was first reported in Lake Michigan near South Manitou Island in May 1949.[1] It is now the most important commercial fish, with 5,981,415 lbs landed in Michigan in 1970 (data from the Michigan Department of Natural Resources). The catch is declining annually, however, from a peak of 13,369,900 lbs. in 1967. The phenomenal increase in the alewife population to peak levels in 1967 was due largely to the absence of predators, since the sea lamprey had decimated the once-abundant, principal predators, lake trout and burbot.[1] The alewife is widely known for its mass mortalities and littering of beaches. Less well known are the extensive ecological changes it has brought about in the aquatic populations of the lake. Alewife dominated (55%) gill-net catches off the Palisades site.[2]

Adult alewife (primarily 2 and 3 year-old) make a massive movement toward shore in early spring (observed at Palisades in May) after spending the winter in the deepest (and warmest) regions of the lake[3] (Fig. V-8). Shortly after reaching warm, shallow water they start dying off in large numbers, for reasons that are still not understood.[1] The die-off is also common in Lake Ontario where this normally marine adult was established when white men arrived. The die-offs and massed schools of still-living fish are an economic burden to bathing beaches and industrial and municipal water intakes. Clues to the reasons for the die-off include the normal salt-water habitat of the adult, normal avoidance of cold waters in the ocean (which they cannot completely escape in the Great Lakes), and internal gas pressure changes resulting from the shoreward movements to shallow, warmer waters in spring.

Temperature changes appear to be related to alewife die-offs during the shoreward movements.[1] Prominent die-offs have been associated with thermal plumes of rivers, although the large numbers of carcasses at the plume edge may be due to the concentrating effect of opposing currents rather than to a greater death rate there. Alewife are attracted to warm waters up to 80-85°F;[4] they may, therefore, school in large numbers at thermal plumes (from rivers or power plants) where the normal mortality would be reflected in large numbers of carcasses. The Palisades thermal discharge may affect the alewife in a similar (if still unknown) manner.

Population pressure from wintering alewife has nearly eliminated the kiyi (Coregonus kiyi), a chub that lived all year in the deepest part of the lake.[1] The shoreward migrations of alewife in spring (and the reverse in fall) pass through habitat of the bloater (Coregonus hoyi), and this species declined markedly in the 1960's as alewife became abundant.

The Palisades thermal plume should have no effect on the maturation of sex products in the majority of Lake Michigan alewife that winter in deep waters of the lake. Should abnormal over-wintering in the thermal plume occur, then maturation may be speeded and spawning occur earlier than usual. The results could be predicted from observations of existing thermal discharges, but few pertinent observations have been made. This may be due to inconsequential numbers of alewife that reside in such discharges or to lack of effort, or both.

During late spring and summer adult alewives are concentrated in shallower areas of Lake Michigan for spawning. Few adults at Palisades were in the inshore area during daylight, but large numbers were found in the surf area at night.[2] At these times the alewife occur in schools and often make excursions up and down shorelines. The existing thermal discharge arrangement will, in all likelihood, intercept these shoreline movements. Migration may be impeded (although the excursions are often random), or the schools may be entrained in the thermal mixing zone and receive thermal shock.

There are no data available on the resistance of alewife to such shocks, and any conclusion about their fate following such an exposure would be speculation. The large fish would likely avoid the warmest portions of the low velocity thermal plume at Palisades in summer when temperatures would be sufficiently high to kill them. Unpublished experimental results by Raney[4] suggest that the preferred temperature of alewife is less than 86°F when acclimated to 88°F. They actively avoided a temperature of 86°F when given a choice between it and 80°F. When adult alewife are schooling along the shore at Palisades (temperature in the 60's), the effluent temperature would be sufficiently high to repel them (Fig. III-8). The principal result will be denial of some living space to the fish, amounting to about 10 acres in mid-summer with the present discharge system. The affected space would be significantly reduced (probably to less than one acre) with a more rapid diffuser system for discharging the cooling water to the lake.[5]

Lake Michigan alewives spawn from early June, when temperatures in spawning areas rise above 60°F, through mid-August, if temperatures remain below 82°F.[6] Although most Lake Michigan alewives spawn in flowing water in tributary streams, spawning is common in the sheltered areas of Green Bay in northwestern Lake Michigan, and occurs occasionally along the unprotected shoreline of Lake Michigan proper when the lake water is warm enough. The warming of localized areas of lake waters by heated effluents and the creation of artificial "tributaries" in the form of discharge channels may facilitate lake spawning by alewives where spawning now occurs only infrequently. The probability of this occurring at Palisades is reduced by the shortness of the discharge channel. When alewife from the general lake area approach spawning condition near 60°F, the discharge embayment will already exceed 82°F, the upper limit for spawning.[6]

The eggs are laid and fertilized in the water column. Male and female spiral upward together from the bottom to the surface, dropping eggs and sperm.[7] The eggs are adhesive, and adhere to bottom materials after settling. Since spawning would occur only near shore, it is unlikely that eggs would be drawn into the cooling water intake 3,300 feet offshore and be subjected to thermal, mechanical or chemical effects.

A high mortality rate of alewife eggs is apparently normal at the spawning temperatures.[6] Experimental incubation showed an average 45% mortality in the first 1.5 days. The mortality rate was lower at cooler temperatures and higher at warmer temperatures.

Optimum survival (about 38% hatch) occurred near 63°F with a sharp decrease below 55°F and above 80°F.[6] These temperatures will still occur along the lake shore at Palisades, although the thermal plume will cause them to occur a few days earlier in the immediate area of the plant.

The relation between temperature and lengths of the incubation period has been described by the equation

$$\text{Time} = 6.335 \times 10^{6}\ \text{Temp.}^{-3.1222},$$

where time is in days and temperature is in degrees Fahrenheit.[6] This equation can be transformed to give incubation rates (as percentages of complete incubation per day) at different temperatures. These rates indicate that there will be insignificant changes in the total incubation time of the drifting eggs due to single passes through the thermal plume should they be deposited in the water column near the discharge outlet (Fig. III-12). Should they settle rapidly to the bottom, they could incubate at temperatures above that of the surrounding lake, and hatch earlier than normal. Calculation of hatching dates would depend upon knowledge of where the eggs settle, an unknown factor at this time. Considerating the abundance of alewife in Lake Michigan, and the prodigious quantities of eggs laid by a single female, the impact of the Palisades discharge on the species would seem to be insignificant.

After hatching in June and July, young alewife school largely in the upper few feet of water very near shore, but as they grow older they disperse rapidly into the warmer surface waters of the open lake. A large school of juveniles was netted along the Palisades shoreline in August during preoperational studies.[2] Interception of schooling juveniles by the shoreline plume may entrain large numbers of these fish. Data on resistance times of young aleqives to temperature extremes are not presently available to esitmate mortalities, if any.

It seems unlikely that near-shore schools would be drawn into the cooling water intake 3,300 feet offshore in water 20 feet deep, although inadequate sampling by Patriarche[2] did show some small alewife at that location in July. The low velocity of the intake flow at the margin of the intake crib has been designed to allow active swimmers such as alewife to swim away. Any fish drawn into the intake piping, however, could not resist the 9 feet per second (fps) flow rate and would be swept onto the traveling screens where mortality is certain. Performance of the intake appeared successful in pumping tests in 1971, for few fish were removed from the intake screens.

The alewife has had a detrimental effect upon other near-shore species. The lake herring (Coregonus artedi) and the emerald shiner (Notripis atherinoides), previously extremely abondant in the shallows, decreased sharply with increases in alewives.[1] Perch (Perca flavescens) initially became more abundant in its normal shallow-water habitat (due presumably to abundant alewife as food), but populations declined sharply as alewives interfered with spawning and hatching in the spring. The alewife has also contributed to a decline in population of the smelt (Oxmerus mordax), which also occupied the inshore areas of the lake.

In the fall and winter after hatching the young alewives occupy the mid-depths of the lake, where they remain until 2 years old. This had also been the rearing ground for lake herring, chubs and smelt.[1]

The alewife appears to be quite susceptible to cold water shock.[1,8] No quantitative data are available, however, with which to predict mortality. The low-velocity thermal discharge at Palisades may allow physiological acclimation to unnaturally warm water, increasing the possibility of deaths due to rapid lowering of temperature (See general discussion of cold kills of fish in Section V.C).

Lake Whitefish (Coregonus clupeaformis)

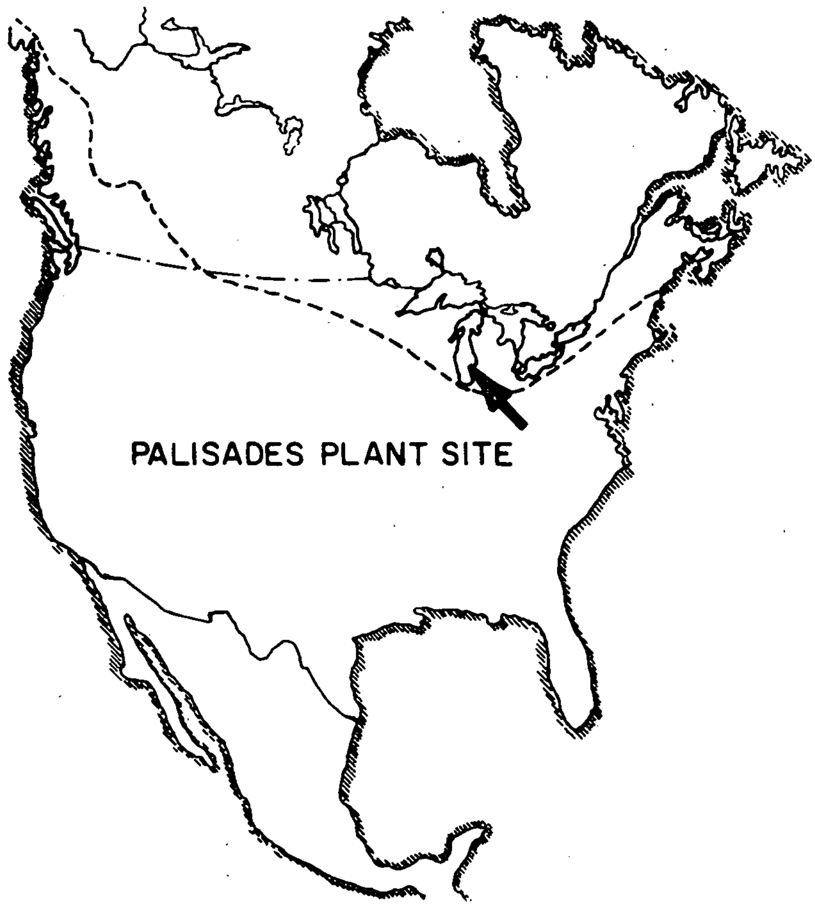
The whitefish was historically one of the most important native commercial fishes in Lake Michigan, but it suffered greatly from sea lamprey predation.[9] Lamprey control programs have allowed a partial comeback, but the species is still not abundant in the southeast sector of the lake.[2] Few have been collected in the preoperational fish studies at Palisades.

The southern limit of distribution of the whitefish is reached at the latitude of the Palisades Plant, and other factors being equal, conditions at that latitude are marginal for successful propagation of this species (Appendix V-2 Fig. 1).[10] Because of intense efforts to reestablish whitefish, however, it is considered here in evaluating potential impact of the Palisades Plant. The species has been a prime matter of debate concerning thermal discharges into Lake Michigan.[8,11] Whether the marginal environment of southern Lake Michigan is to be regulated to enhance this species is a social decision that cannot be evaluated only scientifically. On a strictly scientific basis, the whitefish is not an important constituent of the biota in the region of the Palisades Plant, and maintenance of any sizable population there depends upon exceptionally cool weather conditions or migration of fish from more northern areas.

Because of limited abundance in Lake Michigan, the seasonal distribution of whitefish must be inferred from studies of other lakes, notably, Lake Erie.[10] The Lake Erie example is probably more pertinent to a discussion of Palisades than would evidence from northern Lake Michigan, due to similarity of latitude.

The lake whitefish is usually found in the deep areas of the lake (Fig. V-9). In many lakes there is a migratory movement from deep to shallow water in early spring and a subsequent retreat to deep water again in early summer. Commercial fishermen understand these movements and fish accordingly. During October, November, and December, depending on the geographical position of the lake and the water temperature, the whitefish move from the deeper water to the shallower spawning areas. It seems doubtful that maturation of sex products in whitefish located in the deep hypolimnion could be affected by the Palisades thermal plume. The relative size of the hypolimnion is not expected to be affected by the thermal discharge.[11]

Whitefish spawn over rock, gravel, or sand that is swept clean by currents. The latter is the principal constituent of bottom materials at Palisades.[12] Hart[13] found that whitefish in the Bay of Quinte (Lake Ontario) spawned mostly in water 8 to 15 feet deep.



Outline Map of North America Showing the Southern Limit of Distribution of Lake Whitefish (Coregonus Clupeaformis Mitchill) as Indicated by the Dotted Line (Lawler 1965).

APPENDIX V-2
Fig. - 1

While the spawning areas in Lake Michigan are not precisely known, records of the active whitefish commercial fishery during the spawning seasons before collapse of the populations indicate that the shallow waters of the entire shoreline were utilized.[8] The present populations require a much smaller area, however, and they likely have discrete, but as yet unknown, spawning areas. It is unlikely that there are spawning areas currently in use near the Palisades Plant. Experimental fishing by the U. S. Bureau of Sport Fisheries and Wildlife subsequent to preparation of the Draft Statement found no whitefish near the Palisades Plant (Table 3). This test fishing was done especially to identify spawning whitefish and lake trout in the region of southeastern Lake Michigan.[68]

Whitefish appear to have narrow temperature limits for spawning. Monti[14] found that whitefish did not spawn in Italian lakes where winter temperatures remained above 45-46°F. There is no possibility that Lake Michigan would be heated to that extent, however, by the Palisades Plant's thermal output. Whitefish in the Great Lakes spawn when the lake is cooling, and a drop to 42°F was required to stimulate spawning.[8] Hart[13] identified the necessary range in Lake Ontario as between 40° and 50°F; Lawler[10] observed peak spawning at 43°F in Hemling Lake, Manitoba.

The time of whitefish spawning in Lake Erie varies from year to year and region to region.[10] Spawning may start from early November to the first week in December at temperatures ranging from 49° to 39°F (9.5° to 3.9°C). Records of egg receipts of the Ohio State Fish Hatchery[10] for the years 1928-32 indicate that spawning may extend over a long period and that the number of fish on the spawning grounds may fluctuate during that time, presumably due to fluctuations in temperature. In the fall of 1928, the hatchery began receiving eggs on November 16, when the water temperature was 36°F (2.2°C); the greatest numbers, however, were received from November 26, to December 1, at temperatures between 41° and 36°F (5.0°-2.2°C) which probably represented the peak of the spawning season. The same general situation was noted in other years for which data are available. It can be concluded that spawning in general is delayed until the temperature drops to approximately 46°F (7.8°C) and that the peak of spawning occurs at a somewhat lower temperature. Spawning at temperatures above 43°F (6.1°C) is probably unsuccessful because of the slight chance for successful incubation at higher temperatures.[15]

Should the normal seasonal temperature drop of Lake Michigan be delayed (by an abnormally warm fall, or locally by the Palisades thermal discharge) it may be presumed that peak spawning would occur at a later date. This shift by another fall-spawning species, the chinook salmon on the Columbia River, has been documented by Watson,[16] and similar differences in spawning times from year to year have been observed regularly for a number of fish species. Clearly, this cannot be extended for too long a period, for Pokrovskii, as cited by Lawler,[10] observed that the temperature of the water during the period of spawning exercises an influence on the abundance of year-classes of certain whitefishes and on their yield; in some years the quantity of fertile eggs reached 80 to 100 %, in others it decreased to 30 to 50 %, and in one instance only 10 % of the eggs deposited were fertile. Such low fertility was attributed to prolonged autumns in which the males leave the spawning grounds before the optimum spawning temperature for females is reached.

Based upon estimates of thermal plume dimensions at the Palisades Plant and the average Lake Michigan beach zone temperatures,[8] a maximum of 12 miles (alongshore) of potential spawning bottom would be delayed by more than 4 days, and a maximum of 2 miles would be delayed more than 20 days (assuming 42°F to be the critical spawning temperature).

Whitefish eggs laid on the bottom would not be drawn into the intake of the Palisades Plant in significant numbers. Studies by the Environmental Protection Agency at two Lake Michigan power plants in November and December 1971 where whitefish were known to spawn concluded that passage of eggs through the plants was insignificant.[66] Sampling included a period of severe storm when resuspension would have seemed most likely.

Evidence has been presented by several investigators that shows that whitefish is a species adjusted to a rather narrow range of temperature during its embryonic development, 32.9° to 42.8°F (0.5° to 6.0°C), with the optimum for the species being extremely close to the freezing point of fresh water.[8,10,15] Such a low temperature range limits the occurrence and continued survival of the species to waters which maintain a winter temperature close to the freezing point. The duration of this low temperature is also critical for high production of young fish. Lawler[10] concluded that exceptionally long winters, in which fall temperatures dropped early to 43°F and spring temperatures rose slowly and late, provided the strongest crop of young whitefish in Lake Erie and that this crop was reflected in high whitefish abundance for several years thereafter. One would presume that strong crops of whitefish could be produced near the Palisades Plant (which is at similar latitude) only under similarly exceptional conditions. Favorable temperatures are much more likely to occur in the northern zone of Lake Michigan, the principal area in which whitefish is currently increasing its abundance.

Should whitefish eggs be incubating offshore at Palisades in winter, they would be affected by a sinking plume rather than the normal floating plume of warmer seasons. The warm thermal plume will sink to the bottom when beach zone water temperatures are at freezing since the maximum density of water is at a temperature of 39°F. The discharged water will likely stratify on the surface initially, then sink when cooled to near 39°F and flow along the bottom as a discrete water mass until it mixes with open lake water near 39°F. This phenomenon has not been studied extensively, but its occurrence has been confirmed at operating power plants on Lake Michigan (testimony of J. C. Ayers).[17] The maximum area heated above 42.8°F (the upper limit of the incubation range) at Palisades with the present discharge would be about 100 acres (or about 0.16 mi^2) on a calm day without alongshore currents, based on theoretical considerations.[5] This could be reduced to about 0.6 acre with a single port, high velocity (10.1 fps) discharge at the same location. The bottom area heated to above 35°F would be less than 500 acres (or about 0.8 mi^2), and could be less than 50 acres with outfall design changes. It is doubtful that these affected areas could seriously impair reproduction of a population of whitefish that did (as historically) spawn throughout the shoreline area of the lake. Should the area off Palisades be a favored spawning area for the limited populations currently available (for which there is now no evidence) then these areas could be significant.

One can calculate from the data of Price[15] the effect of such a sinking plume in winter on incubation times of whitefish eggs. It has been suggested[8] that change in timing of hatching may prevent the fry from obtaining the right kinds of food and thus increase mortality.

If incubation is assumed to proceed at a constant 33°F, near the optimum, then about 140 days are required for hatching. At 39°F about 85 days would be required, a difference of 55 days. The assumption of constant temperatures is not realistic, however. Normal incubation takes place on a changing wintertime temperature curve, starting at the spawning temperature of 42°F, dropping to 32°F in January and February, then rising in spring. Daily rates of incubation can be determined by taking the reciprocal of the incubation time. Thus, Price's data indicate a rate of 0.7% per day at 33°F, and 3.3% per day at 50°F.[15] A non-linear rate curve can be constructed from Price's data which allows determination of the daily incubation rate at any temperature chosen.

Using the daily incubation rate information for whitefish, and an average temperature curve for Lake Michigan, the normal incubation period in Lake Michigan was calculated to be 123 days, with hatching predicted on March 28 for eggs laid at 42°F on November 25. This is somewhat earlier than the reported hatching dates of mid-April[13] suggesting that the "normal" Lake Michigan temperature cycle may be somewhat too warm already. This confirms Lawler's[10] observations that occasional exceptionally cold winters are necessary to maintain whitefish at the latitude of the southern portion of the lake. If temperatures do not fall below 39°F (the extreme case of a sinking plume) then hatching is calculated to occur on February 16, after 82 days, a reduction of incubation time from the normal by 41 days.

The thermal plume is unlikely to remain stationary throughout the winter, however. Lake currents are in one direction only about 1/3 of the time.[12] If incubation temperatures are at 39°F for one-third of the time that they normally would be below 39°F, hatching is calculated to occur on March 15, after 110 days - 13 days less than normal. According to Lawler,[10] this reduction would be significant.

Newly hatched whitefish emerge in about April[13] and occupy inshore waters during at least the early stages of their development; limited evidence suggests that those which move into deeper water later in the fry stage inhabit upper levels. The newly hatched fry remain near the surface, and about 2 weeks after hatching begin to school and concentrate in water less than 18 inches deep.[13] About 4 weeks after hatching they moved into water 3 or 5 feet deep, but always remained near the surface. Reckahn[18] found whitefish fry in South Bay, Lake Huron, in shallow areas (less than 3 feet deep) in late June and early July. Studies of the early life history of whitefish now being conducted by the University of Wisconsin-Milwaukee in Green Bay and northwestern portions of Lake Michigan have shown that Lake Michigan whitefish also use the inshore areas for egg incubation and nursery grounds; about 90% of the larvae were at water depths of 10 feet or less.[8]

Few juvenile whitefish would be expected to be pumped into the Palisades cooling water. The intake for the Plant is located 3,300 feet from shore, in about 30 feet of water well outside the probable spawning zone (8 to 15 feet deep) for whitefish, and outside the area inhabited by the fry (<10 feet deep). The intake openings are about 20 feet below the water surface, so fry that move offshore and remain in the upper levels would not be drawn in.

If data were available for this species, we could take the conservative assumption that fry would be drawn in, and calculate whether they would survive the treatment. No data are available on thermal resistance times for whitefish fry, however, so the calculations presented for cisco (a closely related species) must be taken as the nearest approximation. Those calculations suggest that some mortality could be expected, particularly in summer, if fry were present at that time. Some mortality could be expected from mechanical damage, although this is unpredictable with present knowledge. Many power plants have successfully passed fish with no apparent damage, although others have inflicted considerable mortality. The possibility of damage should be monitored closely in the operating facility. Chlorine will be used at Palisades to treat cooling water, and this treatment would kill all fish in the cooling water at that time.

Shoreline-schooling young whitefish (if present at Palisades) are more likely to receive thermal shocks or chlorine toxicity while being mixed with the heated discharge water in the lake itself than by being drawn through the condensers. As noted above, the intake is well located to avoid young whitefish; the present discharge, however, is situated in what would be their densest concentration and utilizes the shoreline water for dilution. Any school of juvenile whitefish migrating along the Palisades shoreline (a behavior observed elsewhere) would invariably find the existing shoreline discharge to be a barrier, and the school could be swept into the plume. Provision of a zone of shoreline passage, perhaps by locating the discharge structure at the 10-foot depth contour, could significantly reduce the probability of entraining schools of young whitefish (or any other shoreline-following species) into the thermal plume.

Estimates presented for cisco suggest that the existing discharge plume would be unlikely to induce thermal shock mortalities in spring. This likelihood could have been reduced even further by added dilution. If juvenile whitefish in summer were unable to avoid being swept into the plume, they would probably suffer some mortality. Precise calculations of survival times are not possible in the absence of sufficient data on thermal resistance of this species.

<u>Cisco</u> (<u>Coregonus</u> <u>artedii</u>) (also called lake herring)

The lake herring, or cisco, was traditionally the most productive commercial fish species in Lake Michigan but it declined sharply after 1954. Although the cause is uncertain, the decline coincided with the establishment and increase of the alewife and there may be a strong incompatibility between the two species. If this is true, it is considered unlikely that lake herring stocks will improve.[9] The commercial catch in Michigan dropped from 84,400 lbs in 1960 to 676 lbs in 1970. Only four individuals were captured in the lake off Palisades in the 1970 surveys by the State of Michigan, all during May in gill nets.[2]

The cisco is a cold-water fish having the southern boundary of its distribution passing through northern Indiana and southern Michigan. It is one of the more temperature tolerant of the coregonid fishes, but is one of the most thermally sensitive of all the fish species that occur at that latitude, and die-offs of this species are common in the summer in certain lakes.[19] Adult ciscos are considered deep-water fish although among the coregonids they are one of the most shallow-water species in the lake. They have never been abundant below 150 feet.[20] They resemble the Atlantic marine herring, for both live in open water (are "pelagic") and feed on plankton.

The cisco remains in the hypolimnion (deeper, cool water) through summer and migrates into shallow water to spawn in late fall (Fig. V-10). Maturation of sex products should not be affected by the Palisades discharge. There is no direct evidence for the locations of cisco spawning near Palisades, but some assumptions may be made from data in the literature. Pritchard[21] reported cisco spawning in the Bay of Quinte in water 8 to 10 feet deep. Colby and Brooke[67] observed cisco spawning over water 0.5 to 3.5 m (1.6 to 11.5 feet) deep in Pickerel Lake, Michigan. While there was some spawning over much of the littoral zone, egg concentrations were highest in two areas that were apparently selected by the spawners. If this depth is also used in Lake Michigan at Palisades, then the spawning area would be considerably inshore of the Plant intake (located at a depth of 20 feet). Koelz[22] and Dryer and Beil,[23] however, found spawning to occur at much greater depths in Lake Superior. Prespawning fish appeared in October on reefs (18 to 36 feet deep) where they were fished heavily until late November. Catches rarely included fish that had spawned. Large scale spawning occurred in water 54 to 120 feet deep to which the fish gradually moved.

Evidence strongly suggest that cisco are pelagic (open water) spawners that show no preference for a particular bottom type.[23] Spawning fish were observed in Lake Superior at water depths of 30 to 90 feet over bottom depths of over 200 feet. Eggs, presumably drifting toward the bottom, were netted at 120 feet. If this pattern holds for the Palisades area, then both spawning adults and incubating eggs would be in lake strata well below the thermal plume and presumably not affected by it.

Cisco spawn from mid-November to mid-December, when the temperature drops from 39 to 37°F.[24] Several other investigators observed that lake herring spawn when the temperature falls below 39°F.[8,25,26,27,67] Cahn[28] found that ripe female lake herring in laboratory tanks would not spawn at 40°F, but would do so after the temperature had dropped to 38.5°F or lower. John[29] reported that lake herring will spawn--later than usual--when temperatures are above 39°F during late autumn, but suggested that the delay may reduce egg survival.

As calculated for whitefish, the small temperature increment added by the Palisades thermal discharge to the general lake would be insignificant in delaying spawning outside the local area of the Plant. Even in the local area, the delay would amount to no more than a few days. This delay should not approach that reported by John[29] nor have the suspected results.

The optimum constant temperature for incubation of cisco eggs has been determined to be about 42°F, with the highest temperature for 50% of the eggs to produce viable fry being 44.6°F.[30] The most temperature-sensitive stages were the early stages of development (gastrulation and organogenesis). If spawning does not occur until 39°F on a declining trend, presumably the available incubation temperatures in an environment heated uniformly above natural will still be lower than the optimum (42°F) and surely below the 50% survival temperature. Unseasonal temperature rises at this time of greater than 3 to 4°F could be hazardous, however, when heating is not uniform. Wafting of the Palisades plume over near-shore spawning sites shortly after egg deposition (which might occur if an along-shore current changed direction) could affect several hundred acres. This critical time would last a few days until ambient temperatures dropped further. The areal extent of the 3 to 4F° rise in the plume would have been considerably less (less than 50 acres under the worst conditions of no wind or lake currents) had a discharge been employed which maximized dilution. Under normal turbulent lake conditions the area would be somewhat less than 50 acres.

If the Palisades plume sinks in winter, as discussed for whitefish, the dense, 39°F plume that expands over the bottom will be cooler than the optimum incubation temperature. The rate of development will be greater, however, than that of eggs at about 32 to 33°F in the surrounding waters. If incubation is assumed to proceed at a constant 33°F, a rise to constant 39°F (the temperature of most dense water) would decrease the time by about 50% to hatch-from about 240 days to about 130 days, a reduction of 110 days (from data of Colby and Brooke[30]). The assumption is unrealistic, however. While temperatures below 39°F predominate in the spawning grounds during the early incubation period from late November through March (about 120 days), they rise sharply thereafter (to over 45°F at the end of April). Normal incubation would thus take much less time than 240 days.

From the data of Colby and Brooke[30] one can calculate the daily rate of incubation at any temperature by taking the reciprocal of the incubation time. Thus, at 33°F the incubation rate is 1/240 of complete incubation per day, or 0.4 % per day. At 50°F the rate is 1/40 of complete incubation per day, or 2.5 % per day. The data points obtained in Colby and Brooke's study form the basis of a non-linear rate curve that allows determination of the incubation rate at any temperature.

Using the incubation rate curve and an average temperature curve for Lake Michigan[8] the normal incubation time was calculated to be about 156 days, with hatching occurring on May 5 for eggs deposited in December. This calculation, based upon laboratory data, agrees quite well with the reported hatching of eggs in nature in late April and early May.[21] If no temperatures occur below 39°F, and the remainder of the cycle is the same (which might occur in deeper water where a non-fluctuating sinking plume, but not the normal floating plume, contacts the eggs) then the incubation time is reduced to 129 days, or 27 days less than "normal." This is in sharp contrast to the hypothetical 110 days difference noted above for incubation at constant temperatures.

It is still unrealistic, however, to assume that a sinking plume in winter will remain over one bottom location constantly. Particular alongshore current directions occur only about 30% of the time at Palisades (although this is averaged for the whole year).[12] If a spawning site has the abnormal 39°F for about 30% of the time in winter, and the fluctuations between 33°F and 39°F are of themselves are not damaging, then incubation would take about 151 days. We are left, then, with evaluating the significance to a natural population of a shift in hatching time of about 5 days. Subsequent to our making these calcualtions for the Draft Detailed Statement, Colby and Brooke[67] have tested the accuracy of their laboratory data for predicting hatching times in the field. Hatching was predicted in Pickerel Lake, Michigan with 1 day (0.8%) of the observed field data in 1969 and within 2 days (1.4%) in 1970.

Larval ciscoes move, after hatching in late April and early May, from the incubation areas along the bottom in 8 to 10-foot depth to protected areas and bays near shore.[21,31,32] Studies in the laboratory and in Pickerel Lake, Michigan by Colby and Brooke[67] have shown the newly-hatched cisco larvae to be positively phototactic, i.e. they rise rapidly to the lighted water surface. If the incubation areas were directly under a stratified thermal plume, the larvae would experience an abrupt temperature rise to levels that may be unseasonably high. The fry apparently school alongshore with whitefish fry until they are about one month old. The migration routes and the schooling areas of the fry would be inshore of the Palisades Plant intake (located at 30-foot depth). The open shoreline of Lake Michigan near the Palisades Plant is notably deficient in protected areas. Beach obstructions, such as the outfall piling and the barge slip used during construction, may increase the protected areas, although not greatly. Faber[32] found small numbers of larvae in surface collections over deep water in Lake Huron in spring. These fish would be more susceptible to being drawn into the Plant intake than would those closer to shore.

Young cisco appear to have some specific food requirements.[8] Fry begin feeding about 6 days after hatching, which is well before the yolk-sac is absorbed. The diet is composed primarily of crustaceans of the order Eucopepoda - suborders Cyclopodia and Calanoida - for the first 2 to 3 weeks (or until they reach a total length of 15 mm) at which time species of the suborder Harpacticoida are found in their gut. The range of mean total length of food eaten (to 0.5 mm) by fry 12 to 18 mm long is less than the mean total lengths of the preferred food available (0.6 to 1.mm). Thus fry are selecting food organisms that are small enough for them to ingest or that have swimming speeds or behavior patterns that enable the fry to capture them. In either case the food organisms ingested are not adults but rather juveniles of a stock that has recently reproduced. Evidence from a food selectivity study shows an increase in abundance of cyclopoid juveniles coinciding with the hatching and appearance of cisco fry. At this time the stock of calanoids is increasing in density but decreasing in average size, indicating a younger population. This population is increasingly fed upon by the fry as the density of cyclopoids drop.[8]

Adult cisco also feed primarily upon zooplankton.[26] <u>Daphnia</u>, <u>Diaptomus</u> and rotifers made up the bulk of stomach contents examined. Such miscellaneous items as cisco eggs (during spawning), <u>Corethra</u> larvae (aquatic insect), and dragonfly nymphs (in quiet shore areas) were also found.

The temperature optimum for growth and survival of larval ciscos appears to be near 50°F, with suitable sustained production occurring between 55 and 65°F.[33] In experiments at constant temperatures, growth rates increased throughout the range tested (about 37.5 to 65°F) but mortality became high above 55°F, thus reducing the net biomass gain by the population.

The near-shore surface temperatures at the Palisades Plant at the approximate time of hatching of larval cisco are about 45°F, although this is likely exceeded in the shallows where the juvenile fish gather.[8] The juveniles are therefore below the optimum for net biomass gain. The advantage of rapid larval growth has been emphasized by Burrows[34] who demonstrated that young salmon of the same age but larger size survive at significantly higher rates. The apparent upper temperature limit for sustained production of the small fish is reached in the early part of July in the near-shore surface waters, after the young would have left.[21]

Taking the conservative assumption that some cisco fry would be drawn into the cooling water, the effects of thermal shock can be estimated based on methods reviewed by Coutant.[35] It is planned that the Palisades Plant thermal discharge elevate the temperature of cooling water 25 F° when operating at 2,200 MWt and 28 F° at the ultimate power level of 2,600 MWt. This higher power level cannot be obtained until several years of operation have passed, however, and by that time the cooling towers should be in operation. Juvenile cisco may be acclimated to near-shore temperatures ranging from about mid 40's in April to low 70's in July and August (Michigan Water Resources Commission data from Benton Harbor, Michigan).[36] The lengths of time that any species can survive very high temperatures are defined by equations of the form: [log time of survival (minutes) = a + b (temperature in Centigrade)]. The coefficients a and b will be different for different species, different life stages of a species, and for different acclimation temperatures of any one life stage. Using data from Edsall and Colby,[37] half of a population of young fish acclimated to mid 40's in spring would survive the 25 F° elevation for 142 minutes, and the 28 F° elevation for 24 minutes. In summer at acclimation temperatures in the low 70's, half of a population would survive the 25F° rise for only 0.04 minutes and the 28F° elevation for only 0.008 minutes (both of these times are essentially instantaneous). About 20% of these times would likely increase the fish's susceptibility to predation.[38] Additional calculations are presented in Appendix V-2, Table 1. A ratio greater than 1 denotes 50% mortality (safety factor = 0) or thermal stress that may lead to secondary mortality form predation, disease, etc (safety factor = 2°C). Method of calculation, is from Coutant;[68] basic thermal resistance data are from Edsall and Colby,[69] and the temperature elevation 25F°.

Since the transit time for cooling water from the condenser head box to the discharge point is about 25 seconds, young fish in spring could be expected to survive this part of the cooling water passage without thermally-induced mortality. This would not be true in summer, when all fish so transported would certainly be killed. It can be estimated that heavy mortalities could occur in the Plant when discharge temperatures reached about 88°F in the spring.

The present discharge at Palisades would probably return cooling water to non-lethal levels in spring after about 1/2 hour under conditions of no wind or lake currents, although no detailed thermal plume model study was conducted by the applicant. This would still not be sufficient time to induce 50% mortality of the entrained organisms at the 25 F° Δt. Clearly, a more rapid cooling through dilution in a high-speed discharge jet would alleviate most mortalities and indirect effects such as predation at these times. Only a severe reduction in the Δt in summer, however, would alleviate mortalities then. On the other hand, the larger summer fish would be much more able to avoid being drawn into the intake structure, and thus the probability of exposure would be considerably less.

APPENDIX V-2 TABLE 1

TIME-TEMPERATURE CALCULATIONS OF JUVENILE CISCO MORTALITY IN THE PALISADES COOLING SYSTEM (CONDENSER PASSAGE AND PLUME ENTRAINMENT).

Acclimation Temperature °C	Acclimation Temperature °F	Cooling Water Temperature °C	Cooling Water Temperature °F	Time Exposed (min)	a*	b*	Safety Factor (°C)	Upper Incipient** Lethal Temperature °C	Upper Incipient** Lethal Temperature °F	Ratio
Condenser Entrainment										
5	41	18.9	66	1.5***	10.28	-0.36	0	21.7	71.1	0.0
5	41	18.9	66	1.5	10.28	-0.36	2	19.7	67.5	0.0
10	50	23.9	75	1.5	12.49	-0.41	0	24.2	75.6	0.0
10	50	23.9	75	1.5	12.49	-0.41	2	22.2	72.0	0.0197
20	68	33.9	93	1.5	17.30	-0.53	0	26.2	79.2	9.02
20	68	33.9	93	1.5	17.30	-0.53	2	24.2	75.6	105.8
Plume Entrainment										
5	41	18.9	66	0****	10.28	-0.36	0	21.7	71.1	0.0
5	41	18.9	66	0	10.28	-0.36	2	21.7	71.1	0.0
10	50	23.9	75	0	12.50	-0.41	0	24.2	75.6	0.0
10	50	23.9	75	4.2	12.50	-0.41	2	22.2	72.0	0.0554
20	68	33.9	93	36(total)	17.2967	-0.53	0	26.2	79.2	---
		33.9	93	6(1st segment)						36.3
20	68	33.9	93	54(total)	17.2967	-0.53	2	24.2	75.6	---
				6(1st segment)						423.

* Coefficients of a regression equation describing thermal resistance at a particular acclimation temperature (data from Edsall and Colby[37]).

** The upper threshold for damage (temperatures below this level are tolerated).

*** 1.5 min. approximates the duration of exposure in condenser piping (25 sec) and in discharge canal (1 min).

**** Assumes continuation of the maximum temperature until the plume has actually cooled to the incipient lethal temperature, or that temperature minus the safety factor, whichever applies.

Should juvenile cisco be drawn through the cooling system, some mechanical damage can be anticipated. The quantity is not predictable with present knowledge, but may be none or much. This possibility must be evaluated in the operating facility.

In summer, adult cisco leave the warmer surface waters for deeper water when the temperature of upper strata reach 68°F.[39] There are apparently no lakes where adult ciscos are distributed in the epilimnion when temperatures there exceed 68°F. The juveniles are more tolerant of high temperatures than are the adults[40] and in another lake (L. Nipissing, Ontario) the two youngest age groups were the last to migrate to the colder hypolimnion in early summer.[39]

Bloater (*Coregonus hoyi*)

The bloater is the principal survivor of a once-diverse group of species called "chubs". Until the 1950's the chub population of Lake Michigan consisted of seven species that had different growth rates, were of different sizes, and occupied different depth zones of the lake. Because of the sea lamprey, alewife and other factors, the bloater was the principal chub remaining by 1963. It is currently about as abundant as all chub species were before the sea lamprey invasion.[9] The chubs, principally the bloater, are commercially important, with over 4 million lbs landed in Michigan in 1970 (Michigan Department Natural Resources data).

The bloater is now abundant throughout the entire deep-water area of the lake.[9] At Palisades these fish occur largely in deeper water (∿72 feet), but apparently migrate inshore in June after which they quickly return to deeper water[2] (Fig. V-11). Adults have been reported to congregate on the bottom of southeastern Lake Michigan at 8 to 10°C (46.4 to 50°F) in late summer.[3] The juveniles occupy open waters during late summer, probably in the thermocline at temperatures above 10°C (50°F). Maturation of sex products of adults will be unaffected by the thermal plume from Palisades occurring in the top 10 feet of the water column.

Coregonus hoyi spawns in March in Lake Michigan, at depths of 120 to 180 feet.[22] Spawning activities and incubating eggs should not be influenced by the thermal plume from the Palisades plant. Juveniles will be well away from the possibility of being drawn into the cooling water and the possibility of thermal, mechanical or chemical damage.

The upper lethal threshold ("ultimate upper incipient lethal temperature") of juvenile bloaters was estimated to be 26.75°C (80.1°F).[41] Resistance times to temperatures higher than this can be calculated from available data. These data are of little consequence to the present evaluation, however, since juvenile bloaters are not expected to occur in the cooling water or thermal plume.

The predominant food items of the chubs in Lake Michigan are the invertebrates Pontoporeia and Mysis relicta.[42,43] Small numbers of a variety of insects in larval, pupal and adult stages, the freshwater snail Valvata sincera and fingernail clams (Sphaeridae) were also found. Cannabalism of their own and other chub eggs was common throughout the year except between July and September. They also ate eggs of the deep-water sculpins. The specific food items varied seasonally and with water depth, but these variations occurred at depths beyond those to be influenced by the Palisades Plant, and will not be considered further here. Newly hatched chubs and adults in shallow water also feed on crustaceans in the zooplankton, principally the copepod Cyclops bicuspidatus and cladocerans.[43]

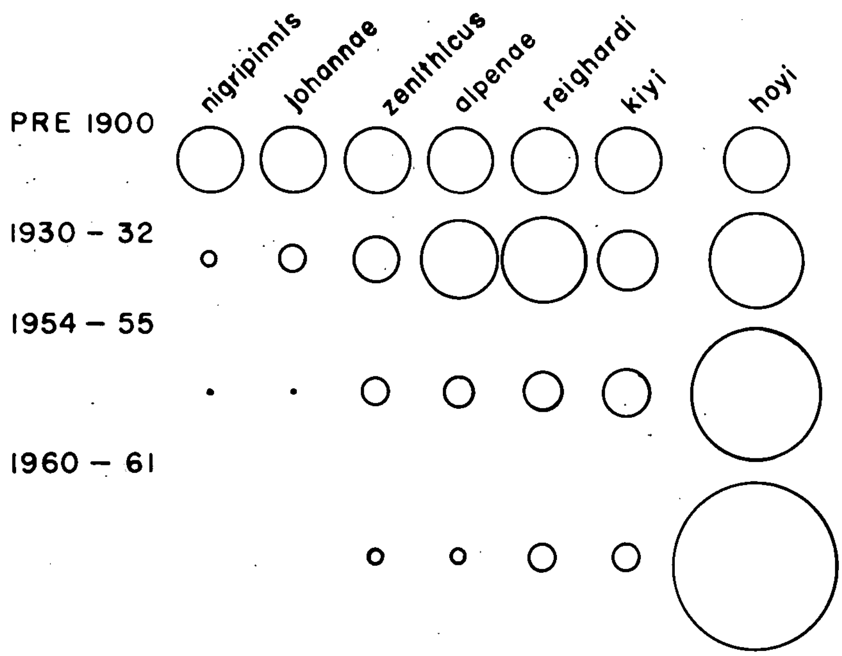
Endangered Species: The Longjaw cisco, Coregonus alpenae

In the United States, 101 species and subspecies of wildlife (14 mammals, 50 birds, 7 reptiles, 30 fishes) are now threatened with extinction.[44] Included in this list is the longjaw cisco, a species that formerly had been common in Lake Michigan.[20]

The endangered existence of C. alpenae is clearly related to different factors than temperature change or other influences likely occur from the Palisades Plant. The principal influences have been the commerical fishery, the sea lamprey and finally, introgressive hydridization with other species.[20] A brief summary follows of Smith's[20] chronicle of change.

The longjaw cisco is one of the deep-water ciscos referred to as "chubs" in the commercial fishery. Intense fishing since the mid-1800's selectively caught the larger fish, a factor that reduced populations of the larger, faster growing species such as C. alpenae and favored populations of the smaller and slower-growing C. hoyi (the bloater). This change is illustrated in Appendix V-2 Fig. 2. It is unclear why the other larger chubs (e.g, zenithicus or reighardi) are not also considered endangered. The competitive position of the smaller species was also enhanced by removal of large predators such as lake trout, first by the commercial fishery and then by the lamprey. The lake trout had fed primarily upon the smaller chubs.

By 1960-61 the two largest deepwater cisco species, C. nigripinnis and C. johannae,[20] appeared to be extinct (Appendix V-2 Fig. 2).



APPENDIX V-2
Fig. 2
Diagrammatic Representation of the Average Species Composition (Percentage) of Deepwater Ciscoes of Lake Michigan in Various Periods. Species Are Arranged in Order of Their Average Size in the Population from the Largest (nigripinnis) to Smallest (hoyi). Assumption of Equal Abundance of Species Prior to 1900 is for Illustration Only. (After Smith 1964)

Commercial fishing records of 1961 and 1962 showed further increase in dominance of chub populations by _C. hoyi_.

Disappearance of the last populations of the larger chub species has been attributed by Smith to extensive hybridization with the dominant _C. hoyi_ for lack of their own species with which to spawn. This conclusion was supported by a high frequency of apparent hybrids in commercial catches, and observed changes in the timing of spawning (especially _C. reighardi_). Smith[20] wrote that the future deep-water ciscos were likely to be different forms (species) than those species recognized in the past (including _C. alpenae_).

Coho Salmon (_Oncorhynchus kisutch_)

The coho salmon, a native of the Pacific coast, was successfully introduced into Lake Michigan in 1966 and is now one of the most important sport fishes. Destruction of large predator fish in the lake by the sea lamprey and explosive invasion by the alewife had left the lake food chain with abundant forage fish but nothing to feed upon them. After thorough study by the State of Michigan Department of Natural Resources,[45] the coho salmon was selected as the first introduction. The first yearling fish, hatched from eggs obtained in Oregon, were planted in 1966 into Bear Creek, a tributary of the Manistee River and into the Platte River in the early spring.[45] By August and September the first catches were being made by commercial fishermen and anglers, and the coho became established as an important species in the lake. Although there is some natural spawning, most reproduction is aided by state fish hatcheries.

Coho juveniles have been stocked recently in several rivers near the Palisades Plant and there are plans for further stocking (Michigan Department of Natural Resources, unpublished data Table 2). These rivers include the Black River (about 4 miles north) and the St. Joseph River (about 25 miles south). The St. Joseph River was also stocked with 100,000 coho in 1969.[46] There is no record of movements of these juvenile fish.

The following annual migration pattern seems to have developed among adults in Lake Michigan[45] (Fig. V-12):

March - April	- Southern Lake Michigan north to South Haven
May	- Southern Lake Michigan north to Holland
June	- Scattered, out in deeper water, southern Lake Michigan

July	- Scattered, including northern Lake Michigan
August	- Over 100-150 foot depth contour; off parent streams
September	- Concentrated off parent streams (some entering streams)
September - December	- Fish in streams, spawning continues

This seasonal pattern seems due, in part, to active selection of favorable temperatures for activity, believed to be 44-58°F, with an optimum near 55°F.[45] With exception of spawning time, coho avoid water warmer than about 60°F. They prefer the upper 30 feet of water if temperature allows. Coho school in summer over the 100-foot depth contour, but at the depth of about the 55°F temperature stratum.

In March and April there are substantial numbers of coho in the lower parts of the St. Joseph and Black Rivers (Clarence Taube, Institute of Fisheries Research, University of Michigan, unpublished data). There is an active sport fishery there in early spring. The attractant to the tributaries is believed to be warmer water (close to optimum) during periods when the lake is still too cold. The warm Palisades plume may further attract coho to the near shore waters during these months.

Adult coho will likely avoid the Palisades plume when and where it exceeds about 60°F. Data are available for thermal resistance times of adult coho from the Columbia River,[47] but the fish in Lake Michigan will not be obliged to pass through the plume except to enter the Black River to spawn. The thermal plume may hasten the normal June migration from shallow water to deep waters several miles offshore. The acceleration of timing would amount to only a few days, however, based upon the plume temperatures and the normal rate of change of lake temperatures.[8]

At spawning time temperature becomes a secondary consideration, and fish may concentrate off parent streams in temperatures exceeding 60°F. When there is an onshore wind from the southwest during September the Palisades plume may extend to the mouth of the Black River and subject adult coho concentrated there to temperatures as much as 3 F° higher than normal. This would be detrimental if temperatures there exceeded 70°F in a large portion of the watermass occupied by the salmon.[47]

<u>Chinook Salmon</u> (<u>*Oncorhynchus tshawytscha*</u>)

The chinook was also introduced from the Pacific Northwest and it has joined the coho as an important species in the lake. First stocking was in 1967. Of the rivers near Palisades, only the St. Joseph has been stocked with chinook to date (Table 2). There are no plans to stock chinook in the Black River.

Distribution patterns for chinook in Lake Michigan are not as clear as for coho, due to the smaller number stocked. The following annual pattern summarizes current knowledge:[46]

April	- Scattered, Lake Michigan
May	- Scattered, Lake Michigan
June	- Scattered, Lake Michigan
July	- Start concentrating off parent streams
August	- Concentrated vicinity of parent streams
September	- Concentrated vicinity of parent stream mouths (some entering streams)
September-December	- Fish in streams, spawning

The chinook appears to be less directed by water temperatures than coho, but this conclusion may derive from over emphasis on the sports catch of adults as an index.

The Palisades Plant does not appear to present a hazard to the known movements of this species. The nearest spawning stream is the St. Joseph River which is beyond all but trivial influence (<1/2°F) of the Palisades plume.

Lake Trout (*Salvelinus namaycush*)

The lake trout has been of outstanding importance throughout the history of fishing in the upper Great Lakes. For many years it supported an annual commercial production of about 15 million lbs and led all species in the value of the catch.[48] It was also important in the sport fishery. A decline or collapse of these fisheries followed the invasion by the parasitic sea lamprey of Lake Huron,[49] Lake Michigan[50,51] and Lake Superior.[52] Recent attempts at sea lamprey control and reestablishment of the lake trout appear to be having success, and thus the impacts of the Palisades Plant on this expanding species, although largely potential, must be evaluated.

APPENDIX V-2 TABLE 2

FISH STOCKING IN LAKE MICHIGAN AND TRIBUTARIES NEAR PALISADES PLANT (1970 & 1971 and proposals through 1974)

(Unpublished Data, Michigan Department of Natural Resources)

Lake Michigan at South Haven

5,000 Rainbow	5/21/71				

St. Joseph River in Barrien County

100,000 Coho	Spring 1970	100,000 Chinook	each year 1972-74	(proposed)
18,000 Rainbow	Spring 1970	100,000 Coho	1972	(proposed)
200,000 Chinook	5/24/71	150,000 Coho	each year 1973-74	(proposed)
20,000 Steelhead	4/28/71	50,000 Steelhead	each year 1972-74	(proposed)
200,000 Coho	3/28/71			

Black River in Van Buren County

50,000 Coho	Spring 1970	25,000 Coho	each year 1972-74	(proposed)
13,500 Rainbow	Spring 1970	75,000 Steelhead	each year 1972-74	(proposed)
54,000 Steelhead	Spring 1970			
16,000 Steelhead	4/29/71			

Kalamazoo River in Allegan County

200,000 Coho	Spring 1970	100,000 Coho	1972	(proposed)
		100,000 Chinook	each year 1972-74	(proposed)
		100,000 Steelhead	each year 1972-74	(proposed)

Over a three-year period of pre-operational surveys for the applicant, 32 lake trout have been captured at the Palisades site.[2] Most were stocked from hatchery-reared juveniles. The young fish had been planted either at nearby Port Sheldon or New Buffalo. There is presently no evidence suggesting that the Palisades area is a particularly high-density area for lake trout. Test fishing for lake trout by the U. S. Bureau of Commercial Fisheries has been done at other locations, the nearest being near Grand Haven.[51] Experimental gill-net fishing by the Bureau of Sport Fisheries and Wildlife in November and December 1971 yielded several lake trout in the vicinity of the Palisades Plant[68] as seen in Table 3. This study was conducted primarily to locate spawning grounds of lake trout and whitefish. The presence of seven ripe females in November and one spent female in December suggests that some spawning may have been occurrring in the vicinity. Wells *et al*.[70] concluded from these data that this species spawned in large numbers along the entire southeastern shore of Lake Michigan.

The following life history description is abstracted largely from the literature reviews by Eschmeyer.[53] Lake trout spend most of their lives in the deeper waters of the cold lakes in which they occur. They move about extensively, however, and may be found at any depths at certain seasons or localities. In the Great Lakes they are usually most abundant at depths between 100 and 300 feet. Generally they live at or near the bottom, but some may occur also in the open water, far offshore. Warming of the surface water normally restricts lake trout to deep water in summer. They seldom remain for extended periods in water with a temperature greater than 65°F; they prefer temperatures of about 50°F. It is extremely doubtful that the Palisades thermal discharge will significantly reduce the volume of cold Lake Michigan water available to the lake trout (based on conclusions of the Great Lakes Enforcement Conference in 1970).[11]

In the lakes where they occur, lake trout are more abundant in some localities than in others, yet they seldom form compact schools. Even the young are scattered and seem to have more or less solitary habits. Fish in Lake Michigan range widely, tagged lake trout having moved more than 200 miles from the place of release. The larger fish moved the greater distances. Smaller tagged fish, less than about 16 to 18 inches long, seldom were recaptured at distances greater than 50 miles from their home waters.

Lake trout spawn once a year, usually in late summer or fall. The date depends on a variety of factors, which apparently include physiological differences among races, physical characteristics of the lake, latitude, weather conditions, and water temperatures. Most spawning is in October

APPENDIX V-2, TABLE 3

NUMBERS OF LAKE TROUT AND WHITEFISH CAUGHT IN VARIOUS LARGE-MESH (5-, 5-1/2 INCH, STRETCHED) GILL NET LIFTS IN SOUTHEASTERN LAKE MICHIGAN[70]

					Lake Trout					Whitefish
Date	Port	Depth (fathoms)	(ft)	Length of net (feet)	Male	Female gravid	Female ripe	Female spent	Total	
Nov. 16[3]	Benton Harbor	3	18	900	55	9	5	5	74	0
Nov. 16[3]	Benton Harbor	5	30	300	10	1	0	2	13	0
Nov. 16[1,4]	South Haven	3	18	600	17	1	5	0	23	0
Nov. 16[1,4]	South Haven	5	30	600	9	0	2	0	23	0
Nov. 17	Saugatuck	3	18	300	37	1	2	0	40	0
Nov. 17.	Saugatuck	3	18	300	24	3	0	3	30	0
Nov. 24[2]	Saugatuck	1	6	300	1	0	0	0	1	0
Dec. 2[5]	New Buffalo	5	30	1,200	26	0	1	0	27	1
Dec. 2[3]	Benton Harbor	3	18	1,200	0	0	0	0	0	0
Dec. 2[3]	Benton Harbor	5	30	600	1	0	0	0	1	0
Dec. 3[4]	South Haven	3	18	1,200	1	0	0	1	2	0
Dec. 3[4]	South Haven	5	30	1,200	2	0	0	0	2	0
Dec. 4	Saugatuck	4	24	1,200	23	0	0	0	23	6

[1]Set from R/V Kaho.
[2]Set from outboard boat.
[3]Set at intake and discharge sites for Cook Plant.
[4]Set at intake and discharge sites for Palisades Plant.
[5]Reef 4 miles south of Cook Plant.

and extends into November in the southern Great Lakes. The duration of the breeding season varies in different waters. It may continue for a month or more in the Great Lakes.

Typical spawning grounds of lake trout are rocky (gravel, rubble, boulders), wave- or current-swept shoals, at water depths that range from a few inches in some inland lakes to as much as 100 feet in the Great Lakes. Even greater depths and a different bottom type were frequented by lake trout of southern Lake Michigan before their near extinction, where spawning occurred on a clay bottom at depths as great as 200 feet and more. Most lake trout production today is from hatcheries, although there are signs of natural reproduction in southeastern Lake Michigan.[70]

Individual male lake trout may remain on or near the spawning grounds for 3 weeks or more, but after the spawning season is over the adult disperse widely from the breeding area. Although lake trout may move to distant points between breeding seasons, most return to the same spawning grounds each year.

Lake trout eggs develop slowly on the bottom in the cold water in which they are laid and may require as much as 4 months or longer to complete their embryonic development. The eggs remain on the bottom and are not resuspended. They thus would not be drawn into the Palisades cooling water intake. Studies by the Grosse Isle Laboratory of EPA during November and December of 1971[66] at two Lake Michigan power plants concluded that passage of eggs through the plants is insignificant, even though spawning in the vicinity was highly probable. The eggs hatch in spring into relatively helpless larvae, about 0.6 inches long, with a large yolk sac and a large mouth. If lake trout spawn offshore of Palisades at the depths (18 and 30 feet) at which they were caught by Wells et al.[70] then incubating eggs would be periodically exposed to the high-density "sinking plume" in winter. The result for timing of hatch may be similar to that for cisco, although the very recent acquisition of the data by Wells et al.[68] from the Bureau of Sport Fisheries and Wildlife precluded any detailed analysis.

Newly hatched lake trout undergo their early development in the protection of the rocks of the spawning grounds. They do not disperse into the shorewaters as do many other juvenile fishes. In about 1 month, after the absorption of part of their large yolk supply, they enter deeper water, beyond the spawning grounds.

The early growth of lake trout, during the period when the yolk is being absorbed, is slow; the rate increases markedly from late July to mid-September, and declines again to a slower rate in the fall. By the end of the first full year of life the average length ranges from 3-1/2 to 5 inches in Lake Michigan. Yearling and 2-year old lake trout have their greatest density at depths of 240-294 feet in Southern Lake Michigan.[48,54]

Lake trout feed almost exclusively on other animals. Except for this generality, the composition of the diet varies widely among fish of different sizes and from different waters. Small lake trout feed first on minute crustaceans and soon add larger crustaceans such as opossum shrimp (when they are available), insects, and small fish (especially sculpins). By the time the fish reach a length of 15 to 18 inches the diet is principally fish. The fishes eaten by lake trout are of whatever kind happen to be available in the immediate environment.

Steelhead Trout (*Salmo gairdneri*)

Since 1965 steelhead populations in Lake Michigan have improved greatly from severe depredation by the sea lamprey. Good runs of this important sports fish are now being observed in most of the traditional steelhead streams tributary to the lake.[55]

Steelhead have been stocked in both the St. Joseph and Black Rivers near Palisades. Another variety of the same species ("rainbow") has been released in the Black River and in the lake at South Haven. Movements of the juveniles are not known.

The steelhead is known for orienting in areas of currents, be they off points, sharp drop-offs, stream mouths or shoal edges. About 5 adult steelhead (probable identification) were observed in the discharge of the Palisades Plant during the site visit in September; they swam freely about in the currents within the discharge canal and periodically swam out into the lake during a half-hour observation. They may continue this practice during cooler months, but probably will avoid the warmer waters in summer. Steelhead avoided warm discharges in the Columbia River during summer spawning migrations.[56]

The annual distribution pattern for this species is unclear.

Perch (*Perca flavescens*)

This native species was the most abundant gamefish in the Palisades area throughout summer and fall. It had been a very important commercial species in Lake Michigan (Michigan catches amounting to 1 to 1.5 million lbs 1960-1963 and 2.3 million in 1964) but it has declined dramatically to insignificant commercial catches in 1970 (Michigan Department Natural Resources data). This decline has been attributed to severe competition with alewife for the nearshore habitat particularly during the spring months when perch spawn.[1]

Perch apparently occupy deep water (>60 feet) during the winter and return to shallow water at Palisades (<40 feet) for spawning after mid-May.[2] (Fig. V-13) Recently, EPA's National Water Quality Laboratory, Duluth, Minnesota, has shown that water temperatures must be 43°F or lower for about 5 months in winter to ensure normal maturation of the eggs within female yellow perch obtained from Lake Superior; higher temperatures during the winter significantly reduced both the number and viability of the eggs that were spawned in laboratory experiments. While this is an important water temperature requirement of the perch, the thermal releases at Palisades could hardly prevent its fulfillment. First, the discharges will not be capable of elevating temperatures of significant portions of deep lake water (>60 feet) above 43°F in winter since the lake basin will be filled with water at maximum density (39.2°F). Neither could they alter the timing of the seasonal drop in temperature to this level by more than a few minutes. Second, although perch in winter would be attracted to warmer water up to their final preferred temperature of about 70°F (21°C),[57] the volume of water at temperatures above 43°F would offer habitat for only a small percentage of over-wintering perch. Should perch populations become rare due to other causes, then the attraction to the warm discharge might be significant, and attempts should be made to restrict the area above 43°F, for example by the use of a high-velocity diffuser discharge port.

The general spawning season for perch in Lake Michigan begins about May 15 and ends about July 1.[8] Optimum spawning temperatures appear to be 46-54°F; at 61°F spawning is reduced and at temperatures above 62°F eggs are aborted without being fertilized (unpublished data, EPA's National Water Quality Laboratory, Duluth). Temperatures above 64°F prevented successful incubation of greater than 50% of perch eggs in experiments at the National Water Quality Laboratory (unpublished). The greatest fry survival was observed at 61°F. There is considerable evidence from the widespread latitudinal distribution of perch that spawning would occur slightly earlier in the year if the appropriate temperatures appeared slightly earlier, and that the higher temperatures would not be experienced in the critical stages.[58]

The area of Lake Michigan near the Palisades Plant does not appear to be suitable for spawning of perch, which require weeds or rocky shoals on which the ribbons of adhesive eggs can attach.[8] The bottom material of the lake at Palisades has not received careful study, but knowledge of nearby areas (near Saugatuck 20 miles north and near Bridgman 35 miles south) appears to be indicative of the Palisades condition.[12] Both of these sites had fine sand to gravel within a few feet of shore. Shifting sand predominated in and between two submerged bars, about 300 and 600 feet, respectively, from shore. Occasional patches of clay-like glacial till and gravel were found between the bars. These patches of gravel seem to be the only feasible spawning sites.

The pressures of abundant adult alewife in the shore area apparently force many perch to deeper water in summer.[1] Young-of-the-year occupy the zone between 3 and 18 feet at the Palisades Plant; few are found in the turbulent beach area.[2] This corresponds to catches by the U. S. Bureau of Commercial Fisheries largely near 16 feet.[8]

Perch in Saginaw Bay, Lake Huron, were found to consume a wide variety of food materials.[59] No comparable studies have been made near the Palisades Plant. Immature insects were dominant, primarily midge fly larvae and pupae and mayfly nymphs. Cladocerans (Daphnia, Sida, Halopedium, Alona) were next most abundant. Amphipods (mostly Gammarus) were important in some ocations. Snails and fingernail clams appeared commonly, as did copepods (Cyclops, Diaptomus), water mites, ostracods, and isopods. Fish first appeared in stomachs of perch over 4 inches in length, and this component of the diet was believed to increase with size; smelt and young alewives are the principal species. There was a sexual difference, perhaps related to the observation made elsewhere that the sexes school separately (several references cited by Tharratt).[59] Fish were more abundant in females (that presumably feed in shallows or open water) and insects were more abundant in males (presumably more feeding on the bottom).

The Palisades thermal discharge would not disrupt the supply of aquatic insects from the bottom since benthic life is not abundant in the "sterile zone" where the plume contacts the bottom. Supplies of young alewives, smelt, and zooplankton may be more readily available in the currents of the discharge, due to some mechanical damage or disorientation.

American Smelt (Osmerus mordax)

The American smelt is native to the northern Atlantic coast and Lake Ontario, and was introduced to Lake Michigan and the other upper lakes by stocking in 1912 and thereafter. It has subsequently become widespread and abundant throughout the four upper lakes.[60,61] It is an important commercial species, with catches in the State of Michigan (one of the states with low catches) exeeding a million lbs since 1966 (Michigan Department of Natural Resources data). The major fishery is in the Green Bay area of Lake Michigan.[62] There is an intense sport fishery for the spawning-run adults; dip nets are used to capture migrating fish in many streams tributary to the Great Lakes. The sport catch may be double the commercial catch.[62]

The species tends to occupy intermediate depths in the shallower waters in Lake Michigan although juveniles frequent the surface layers during their first year[3] (Fig. V-14). Adult smelt were caught in trawl tows at 72 feet at Palisades in May.[2] They move to deeper and cooler water in mid-summer, returning to shallower depths as temperatures drop in autumn. The fish move in slowly moving schools, particularly the young, that are composed of fish of about the same size. The young fish often school close to shore.[3]

Schools of smelt may be vulnerable to entrapment in the Palisades intake since yearlings were caught in trawl collections at that depth off Palisades,[2] and Wells[3] noted abundant juveniles in the surface waters near shore off Saugatuck, Michigan. The low velocities designed for the intake structure, however, appear to mitigate against schools of adults being drawn in. Swimming speed data are not available for smelt to compare with intake velocities. If juveniles school close to shore they may be subject to entrainment in the thermal plume, much as schools of young alewife already discussed. There are no data available on resistance times to thermal shock which could be used to predict mortalities or on preferred temperatures with which to predict attraction or avoidance. It is also impossible to predict mechanical damages.

Spawning is in early Spring in tributary streams and also in shallow parts of the lake.[63] The spawning temperature has been reported to be about 50°F, with mature adults entering tributaries when the stream has warmed to 39-42°F. There is no data available on requirements for gonad maturation, but this process can likely proceed uninterrupted in the open lake in winter. The tributary spawning and incubation process apparently occurs completely outside the range of the Palisades facility, so will not be considered further here. There is no direct evidence for shoreline spawning near Palisades. Once hatched, the fry rise close to the stream surface and drift downstream and thus would enter the shore waters of Lake Michigan. The thermal discharge from the Campbell Plant does not appear to be used as an artificial tributary in spawning runs, so it is unlikely that the Palisades discharge would be used.

Available evidence suggests that smelt is a versatile feeder.[61] In Saginaw Bay, Lake Huron, crustaceans (copepods and cladocerons) are the principal food of young-of-the-year. Rotifers, small eggs, and some algae were also found. The species composition of the food groups probably reflected seasonal availability. Older smelt shifted partially to a diet of aquatic insects (mayflies _Hexagenia_ and _Ephemera_) and fish (almost all _Notropis_ species or young smelt) although the crustaceans remained abundantly utilized. In Green Bay the most important food item, by a wide margin, was *Mysis*, while *Hexagenia* mayflies were poorly represented.[64] Sculpins and burbot were the principal fish eaten. Studies in Lake Superior by Hale cited by Anderson and Smith[65] indicated feeding more similar to Green Bay. Amphipods (both *Gammarus* and *Pontoporeia*) were heavily used also. Most of the differences seem attributable to differences in availability of food species at the various locations.

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APPENDIX XII-1

Comments on the Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consumers Power Company for the Palisades Nuclear Generating Plant - Docket No. 50-255, Issued February 29, 1972, and Responses on Comments With Respect to Environmental Considerations from the Applicant.

1. Advisory Council on Historic Preservation, March 9, 1972
2. Department of Agriculture, April 3, 1972
3. Department of the Army, March 22, 1972
4. Department of Commerce, April 4, 1972
5. Environmental Protection Agency, April 4, 1972
6. Federal Power Commission, March 22, 1972
7. Department of the Interior, April 7, 1972
8. Department of Transportation, April 13, 1972
9. State of Michigan, Department of Natural Resources, May 2, 1972
10. State of Michigan, Department of Natural Resources, May 19, 1972
11. State of Michigan, Department of Public Health, May 4, 1972
12. Township of Covert, Van Buren County, March 24, 1972
13. Consumers Power Company, May 3, 1972
14. Consumers Power Company, May 12, 1972
15. Consumers Power Company, May 19, 1972
16. Department of Health, Education, and Welfare, June 8, 1972

ADVISORY COUNCIL
ON
HISTORIC PRESERVATION

WASHINGTON, D.C. 20240

RECEIVED
MAR 13 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

March 9, 1972

Dear Mr. Rogers:

This is in response to your request for comments on the environmental impact statement identified by a copy of your cover letter attached to this document. The staff of the Advisory Council has reviewed the submitted impact statement and suggests the following, identified by checkmark on this form:

____ The final statement should contain (1) a sentence indicating that the National Register of Historic Places has been consulted and that no National Register properties will be affected by the project, or (2) a listing of the properties to be affected, an analysis of the nature of the effects, a discussion of the ways in which the effects were taken into account, and an account of steps taken to assure compliance with Section 106 of the National Historic Preservation Act of 1966 (80 Stat. 915) in accordance with procedures of the Advisory Council on Historic Preservation as they appear in the Federal Register, February 20, 1971.

____ In the case of properties under the control or jurisdiction of the United States Government, the statement should include a discussion of steps taken to comply with Section 2(b) of Executive Order 11593 of May 13, 1971.

✓ The final statement should contain evidence of contact with the Historic Preservation Officer for the State involved and a copy of his comments concerning the effect of the undertaking upon historical and archeological resources.

____ Specific comments attached.

Comments on environmental impact statements are not to be considered as comments of the Advisory Council in Section 106 matters.

Sincerely yours,

Robert R. Garvey, Jr.

Robert R. Garvey, Jr.
Executive Secretary

cc: Mr. Samuel Milstein, State Liaison Office for Historic Preservation, w/c of inc.

THE COUNCIL is charged by the Act of October 15, 1966, with advising the President and Congress in the field of Historic Preservation, recommending measures to coordinate governmental with private activities, advising on the dissemination of information, encouraging public interest and participation, recommending the conduct of special studies, advising in the preparation of legislation, and encouraging specialized training and education. The Council also has the responsibility to comment on Federal or Federally-assisted undertakings that have an effect on cultural property listed in the National Register.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

April 3, 1972

Director Lester Rogers
Division of Radiological and
Environmental Protection
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

We have had the draft environmental statement for the Palisades Nuclear Generating Plant, Consumers Power Company, Inc., Jackson, Michigan, reviewed in the relevant agencies of this Department. Comments from the Soil Conservation Service follow.

The proposed plan will not adversely affect any present or planned project of the Soil Conservation Service.

This project does not involve any prime agricultural land so doesn't directly affect the crop production base of the county. Erosion and sedimentation will be held to a minimum with watercourses either sodded or cemented. Runoff water from the site should be of satisfactory quality.

By protecting the native trees there will be adequate protection for wildlife and the esthetic view of the area. It is suggested that when additional plantings are made that it include wildlife food plants. When construction work is being done and earth is being moved, we recommend that precautions be taken to keep siltation to a minimum and that the disturbed area be seeded immediately after shaping is completed.

We appreciate the opportunity of commenting on this proposed project.

Sincerely,

T C Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1027
DETROIT, MICHIGAN 48231

IN REPLY REFER TO
NCEED-ER

Mr. Lester R. Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your draft environmental statement transmitted on 3 March 1972 concerning the Palisades Nuclear Generating Plant being constructed by the Consumers Power Company, Inc., Docket Number 50-255.

Since our last response regarding this facility, NCEED-ER, 13 December 1971, the District Engineer has received the completed parameter for the chemical element, BORON. This information has been transmitted to the Environmental Protection Agency. However, the Michigan Water Resources Commission has not yet certified the company's application for discharge permits nor has the concurrence of the Environmental Protection Agency been obtained.

This office has no further comments to add to those furnished in previous correspondence. We would appreciate the opportunity to review the final environmental statement.

Sincerely yours,

Thomas J. Woodall

THOMAS J. WOODALL
Major, Corps of Engineers
Acting District Engineer

Copy furnished:
Mr. Timothy Atkeson, General Counsel, CEQ,
Executive Office of the President, 722 Jackson
Place, N.W., Wash., D. C. 20505
(10 cys of ltr w/o statement)

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

April 4, 1972

Mr. Lester Rogers, Director
Division of Radiological &
Environmental Protection
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

The draft detailed statement on the environmental considerations, by the U.S. Atomic Energy Commission, for the Palisades Nuclear Generating Plant of Consumers Power Company, Incorporated, Docket Number 50-255, which accompanied your letter of March 3, 1972, has been received by the Department of Commerce for review and comment.

In order to give you the benefit of the Department's analysis, the following comments are offered for your consideration. In addition, our detailed analysis related to radiological aspects are appended as part of this transmittal.

The statement on the Palisades Nuclear Generating Plant seems unusually thorough and comprehensive in its treatment of probable impact and potential adverse effects of plant operation on the aquatic environment and ecology of Lake Michigan in the vicinity of the plant site. Our specific comments on this statement are listed below:

Impingement on intake screens is duscussed on page 96, and it is recommended that accurate records be kept of numbers, sizes, and types of fish actually killed. It would be desirable to include here some consideration of the possibility and feasibility of alteration or screening of the intake crib to avoid excessive mortality of fish if such mortality is judged to be significant.

On page 97, second paragraph, it is stated that dilution patterns for waste heat and residual chlorine will be the same. Documentation to support this contention should be presented.

On page 101, first paragraph, it is contended that the seasonal pattern in the rate of photosynthesis, as it may be affected by artificial temperature increases, has not been studied adequately at any power plant. It would seem that in view of the uncertainty owing to the lack of information on the effects of heated discharges on photosynthesis of phytoplankton, the total impact that could potentially result from withdrawal and discharge of water at elevated temperatures by all the present and planned nuclear (and fossil fuel) power plants bordering the lake should be examined. In this connection, it would be desirable for the EIS to address itself to the potential cumulative effect of heat addition to Lake Michigan over, for example, the next three decades. (This comment could apply to the potential long-term impact of all power plants on all components of the ecosystem.)

On page 116, third paragraph, we suggest that the second sentence might be amended to read ". . . human influences--including commercial fishing, the effect of penetration of the sea lamprey into the upper Great Lakes due to opening of the Welland Canal around Niagra Falls, and introduction of salmon. . ."

On page 127, paragraphs three and four seem to be mutually inconsistent. Paragraph three states that the Palisades discharge can be expected to induce toxic concentrations of chlorine over sizable areas, whereas paragraph four indicates that limitation of concentration to 0.5 ppm at the point of discharge to one hour once per month will reduce the adverse impact on the aquatic biota near the plant site.

The discussion of the ecological monitoring program on page 129, second paragraph,indicates that the original program has been modified to meet broader sampling objectives. The wording on pages 133 and 134 gives the impression, however, that some of the components of the modified sampling program are not mandatory, but would be useful. It would be helpful if this ambiquity could be removed. In addition, the extension of the ecological and environmental monitoring program to the first two years of closed-system operation (mentioned on page 213) should be mentioned in this section.

The estimates of damage on page 138 seem misleading in that the effects on fish eggs, fish larvae, and lower trophic levels may have a greater impact than a relationship premised on a one-to-one correspondence between organisms killed and commercial fish catch. Since the actual physical damage would have to be estimated by a sophisticated model, and since the average market value of commercial species is not necessarily a good indicator of the total value to society of the aquatic resources damaged, we suggest that this section be altered to indicate that due to the intangible nature of many of the values involved, fully adequate and realistic monetary evaluation of the damage may be virtually impossible.

As stated in the comment directly above, we feel that the methodology used on page 138 to estimate damage may not be fully adequate, and we therefore suggest that the second paragraph on page 150 pertaining to estimates of damage resulting from operation with the closed cooling system be modified to reflect the difficulty or impossibility of monetary quantification of damages.

Costs of alternative cooling systems are discussed on pages 199-201. It would seem appropriate to list the back-fitting costs for alternatives other than mechanical induced-draft wet towers, in view of the probability that dry cooling towers might be less damaging to the aquatic and terrestial environment.

On page 205, third paragraph, figures for estimated biological damage are again presented. Since there are many methodological problems associated with monetary quantification of biological damage, we suggest that this paragraph be revised to reflect the non-monetary nature of many of the values that would be affected.

Reference is made on page 205, fifth paragraph, to the minimal impact of the Palisades plant and to the AEC's opinion that further expenditure to protect the environment is not justified. Although the ecological impact from operation of the plant as built may be small, we submit that because we do not yet fully understand the long-term impact that nuclear power plants may have on the environment, provisions to protect the environment are justified. Without raising the issue of consumer willingness to accept the higher prices for electricity necessary for environmental protection (given as 0.1 mil per kilowatt hour on page 201), the total impact on Lake Michigan ecology from the numerous nuclear generating facilities being built or in the planning stages may not be small. Therefore, we suggest that the statement not view the resource cost of provision of various alternate cooling systems at Palisades in isolation from the need to provide overall constraints on the magnitude of man-induced effects on Lake Michigan ecology. An addition to this paragraph might be appropriate. This addition should stress the point that the need to consider the total impact on Lake Michigan aquatic ecology from man's numerous and diverse activities may provide reasonable justification for making provisions to modify, if necessary, the plant cooling system.

Regarding the sixth paragraph on page 205, we feel that the statement should reflect concern over the potential contribution of this plant to the overall problem of deterioration of the quality of Lake Michigan. Therefore, we suggest that a statement be added to the paragraph indicating that provisions for closed system cooling will insure that the impact from the heated effluent is reduced to a minimum.

Since specific information on meteorological assumptions, effluent release characteristics, and effluent release duration are not available in the AEC Draft Statement, we are unable to evaluate the radiological consequences of routine and accidental gaseous emissions. Furthermore, the various individual and cumulative radiological doses listed by the AEC and the applicant do not agree. Consequently, we cannot assume that the meteorological assumptions listed by the applicant on pages 2-25 through 2-35 in the document "Supplemental Information on Environmental Impact of Palisades Plant, November 3, 1971" are the same as those used by the AEC. Also, it is not clear why for some releases an annual atmospheric diffusion rate was used by the applicant while on other types of releases either a 24-hour or 2-hour diffusion rate was used. Further comments on the radiological aspects are detailed in the appended remarks.

With regard to benefits, there is an apparent inconsistency: Page 210 states that benefit gained by the use of the visitor's center is $300,000 per year. According to page 203, however, the benefit is estimated to be $100,000 per year.

Whatever merit the statement shown below may contain, it does not follow from the previous discussion but might be strengthened if it could be substantiated.

> "Without the Palisades Plant, system deficiences may cause industrial slowdown, which means reduced individual incomes, and may adversely affect critical public functions such as hospitals, water supply, and sewage treatment." (p. 204)

We recognize that current technology for generating plants, transmission lines and reduction of transmission line losses limits planning to its present basis. However, over the long-term -- from a national viewpoint with regard to the energy situation -- the overall question stated below appears worthy of consideration. The requests for operating and construction permits are considered individually. What would be the effect on the growth in supply of power generation if applicants in the various regions each based their generating capacity requirements on a projected national growth in demand of 7-8 percent?

We hope these comments will be of assistance to you in the preparation of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Subject: Docket No. 50-255 - Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License for the Palisades Nuclear Generating Plant

As in the past, comments presented here refer only to questions of radiation effluent and the radioactivity monitoring program.

The Palisades Nuclear Generating Plant uses a pressurized-water reactor (PWR) having an initial rating of 2200 megawatts thermal (MWT) with an output of 715 megawatts electrical (MWe). There is one reactor unit on the site. It is thus quite similar in many respects to three other plants for which we have previously made comments; Calvert Cliffs, Point Beach, and Turkey Point. All three of these plants have two reactors at the site as compared to one for the Palisades Plant. The power rating of these three units (each unit) span the power rating of the Palisades Plant.

For each of the above three cases the AEC staff have projected the annual release of radioactive material, both gaseous effluent and liquid effluent (each reactor unit), to be identical and as given below in Table I.

Table I. AEC Staff Postulated Annual Release of Radioactive Material in Effluents from Calvert Cliffs, Point Beach, and Turkey Point for Full Power Operation (one unit)

Liquid Effluent

Mn-54	3.0%)	
Co-58	25.4%)	
Co-60	4.2%)	
Sr-89	14.8%)	
Sr-90	1.8%)	10 curies
I-131	24.0%)	
I-133	9.5%)	
Cs-134	5.7%)	
Cs-137	11.6%)	
H-3		1000 curies

Table I (Cont'd)

Gaseous Effluents (30-day holdup)

I-131 + particulate matter		0.1 curies
Kr-85	6.9%)	
Xe-131m	2.5%)	
Xe-133m	0.02%)	5,000 curies
Xe-133	90.6%)	

The anticipated annual release of radioactive material from the Palisades plant for gaseous effluent and liquid effluent given in the draft are given in Tables III-5 and III-6 reproduced below.

Table III-5 appears to be misleading in that the three columns of source terms can only be understood in terms of the total release if a 60-day holdup factor has been applied to these columns where appropriate. If this is correct these three source columns should be so marked.

Please note that the first line of addition in Table III-5 is incorrect. If one takes the three source figures and compares them with the 30-Day Holdup figure, one gets a number of 634 Ci per year rather than a 643. I think it is simply a transposition of the numbers.

A comparison of Table I and Table III-5 for those isotopes listed in Table I shows that the only large discrepancy is in the expected release of I-131, where the anticipated release of the Palisades plant is about 33 times that anticipated for the other reactors as indicated in Table I. The possibility of using charcoal adsorbers to reduce the effluent of gaseous radioactive iodine is discussed on page 202 where it is pointed out that charcoal adsorbers are used in most modern PRW facilities. There is, however, no indication that the applicant proposes to add these charcoal adsorbers in his modification of the rad waste system. It is clear that addition of these charcoal adsorbers would be very beneficial in reducing the gasious radioactive iodine effluent.

It is also indicated on Table III-5 that the Technical Specifications will limit the release of I-131 to 0.8 Ci/yr, a value which is only about 25% of the anticipated release. It would be helpful if the draft statement would indicate in what manner this limitation would be achieved. Such information was given for limitations on liquid effluent as discussed below.

The expected liquid effluents from the Palisades plant listed in Table III-6 differ radically from those listed in Table I, the most prominent difference being in the anticipated release of I-131, where the anticipated I-131 release exceeds that of Table I by a factor of 30. A part of the reason for these differences comes from the text where it is indicated that the values listed in Table III-6 do not include possible reduction in Steam Generator Blowdown and Dirty Waste levels when these effluents are passed through demineralizers prior to release to the atmosphere. The effectiveness of these demineralizers (except for yttrium, molybdenum, and tritium) is indicated on page 70 to be a reduction of 100 in the released effluents. However, it is indicated that these demineralizers will be used only a portion of the time as needed to reduce effluence levels.

The discussion on page 70 indicates that to meet the Technical Specifications proposed by the applicant, about 80% of the dirty waste (which would presumably include the steam generator blowdown) would have to be processed through the radwaste demineralizers, I-131 being the controlling isotope. This would result in the annual release from the "dirty waste" system of about 25 curies per year, still substantially above Table I. It is difficult for the reader to understand why a demineralizer system which can handle 80% of the dirty waste, and presumably 100% for some periods of time, should not be used 100% of the time so as to reduce emissions even further. Such practice would seem to come under any reasonable definition of keeping effluents "as low as practicable."

Most of the above discussion regarding liquid effluents applies to the period of operation before the modified radwaste system is installed. After installation of this system liquid effluents should be very small. Part of the reason for presenting some of the above discussion is to illustrate points made earlier in our commentary on the draft statements for the Turkey Point plant and the Point Beach plant. As the number of draft statements for different plants of similar nature grows, differences between the expected effluents from these plants will become more evident and difficult to assess. This problem could be alleviated if the AEC staff would prepare a specific and detailed report for the basis of their effluent estimates for reactors of a specific type. The report could then be attached as an appendix to draft statements on other power reactors of the same type. The new material required would then be a discussion of the differences expected from the different radioactivity waste handling systems and the consequences and reasonableness of these differences.

No information is given regarding the on-site radiation monitoring program or the ability of the applicant's on-site radioactivity monitoring programs to satisfy the requirements of "Safety Guide 21-Measuring and Reporting of Effluents from Nuclear Power Plants," dated December 29, 1971. We believe that the monitoring program should be described and would contribute to the completeness of the statement. The need for this information in the statement is especially emphasized by the fact that the proposed Technical Specifications for operation of this plant will limit the radioactive effluents to less than those projected in Tables III-5 and III-6. The assurance that these limits are not exceeded can only be assured by an adequate on-site monitoring system.

TABLE III-5

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN GASEOUS EFFLUENT FROM THE PALISADES PLANT

Isotope	Sources			60-Day Holdup*	30-Day Holdup**
	Containment Purge (Ci/yr)	Gas Processing System (Ci/yr)	Steam Generator Leakage (Ci/yr)	Total (Ci/yr)	Total (Ci/yr)
Kr-85	12.8	620	2.1	641	643
Kr-87	0.04	-	2.83	2.87	2.87
Kr-88	0.3	-	9.05	9.35	9.35
Xe-131m	9.6	20.6	3.44	33.6	77.5
Xe-133	996.	42.9	676.	1716.	2640.
Xe-135	0.34	-	3.13	3.47	3.47
Xe-138	0.007	-	2.09	2.09	2.09
I-131***	2.27	-	1.00	3.27	3.27
I-133	0.34	-	0.47	0.81	0.81

*Design basis holdup for the gas-processing system following installation of the modified gaseous waste system.

**Design basis for present gas-processing system.

***The Technical Specifications will limit the release of this radioisotope to 0.8 Ci/yr.

TABLE III-6

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN LIQUID EFFLUENT [FROM PALISADES PLANT*]

Nuclide	Steam Generator Blowdown (Ci/yr)	Clean Waste (Ci/yr)	Dirty Waste (Ci/yr)
Rb-86	0.0263	0.00266	0.175
Sr-89	0.0236	0.00444	0.182
Sr-90	0.00080	0.000214	0.00669
Y-91	0.0550	4.0	0.430
Zr-95	0.00382	0.000779	0.0301
Nb-95	0.00359	0.000575	0.0267
Mo-99	6.73	0.739	9.25
Ru-103	0.00269	0.000458	0.0203
Ru-106	0.00070	0.000180	0.00584
Te-129m	0.187	0.0274	1.286
I-131	12.46	0.341	59.4
Te-132	0.846	0.000698	0.00394
I-132	0.126	$< 10^{-6}$	$< 10^{-6}$
I-133	4.22	$< 10^{-6}$	0.0496
Cs-134	0.303	0.0795	2.533
I-135	0.674	$< 10^{-6}$	$< 10^{-6}$
Cs-137	0.307	0.0824	2.578
Ba-140	0.0237	0.00152	0.141
Ce-141	0.00405	0.000624	0.0299
Ce-144	0.00244	0.000616	0.0202
Nd-147	0.00124	0.000064	0.00697
Pm-147	0.00030	0.000079	0.00251
Cr-51	0.0234	0.0327	0.168
Mn-54	0.0211	0.00536	0.175
Mn-56	0.0303	$< 10^{-6}$	$< 10^{-6}$
Co-58	0.666	0.139	5.272
Fe-59	0.0261	0.00468	0.199
Co-60	0.0204	0.00544	0.171
Fe-55	0.0469	0.0124	0.392
Total	**27 Ci/yr**	**5.5 Ci/yr**	**83 Ci/yr**

H-3 . . . . 1000 Ci/yr

* Releases are based on discharges prior to installation of modified radioactive waste system.

ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D. C. 20460

OFFICE OF THE ADMINISTRATOR

4 APR 1972

Mr. Manning L. Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muntzing:

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Palisades Nuclear Generating Plant. Our detailed comments are enclosed.

We appreciate the difficult circumstances and time restrictions under which the Atomic Energy Commission must prepare a series of complex impact statements. We also recognize the difficulty in determining the appropriate degree to which an agency should go in developing and providing data to support conclusions reached in the impact statement. It is our judgment, however, that this statement should contain additional information in order to evaluate fully the environmental impact of the operation of the Palisades plant. We therefore recommend that the final impact statement contain the additional information outlined in our detailed comments.

The major impact of Palisades nuclear plant prior to December 31, 1973, when the mechanical draft cooling towers are to be operational, will result from thermal discharges. Although these discharges will exceed criteria recommended by the Lake Michigan Enforcement Conference, we accept interim operation of the Palisades plant using once-through cooling with the understanding that the proposed closed-cycle cooling system be installed in accordance with the agreed upon schedule.

Once the closed-cycle cooling system is operational, the major environmental impact will be from chemicals in the cooling tower blowdown. As presently designed, this closed-cycle system will not provide for blowdown treatment. EPA recommends that a blowdown treatment system be included as an integral part of the cooling tower design.

The most significant radiological impact due to routine operation of Palisades will be from radioiodine discharges through plant ventilation systems. In order to achieve low as practicable iodine discharges, we recommend the installation of charcoal adsorbers for the plant ventilation systems.

We will be pleased to discuss our comments with you or members of your staff.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

March 1972

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

EPA#D-AEC-00041-25

Palisades Nuclear Generating Plant

APPENDICES

TABLES

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Palisades Nuclear Plant Unit 1 prepared by the U.S. Atomic Energy Commission and issued on March 2, 1972. Following are our major conclusions:

1. The use of closed-cycle cooling after November 1973, will satisfy the recommendations of the Lake Michigan Enforcement Conference (LMEC). Also, operation of the plant with once-through cooling until November 1973, will be acceptable to EPA, even though the interim once-through cooling system cannot meet LMEC criteria and is expected to result in some environmental damage.

2. Damage to aquatic organisms resulting from entrainment in the proposed 60,000 gpm blowdown dilution flow could be eliminated by discharging the blowdown without dilution. Since this would result in a proportional increase in concentration of radioactive and chemical waste discharge to Lake Michigan, the impact of these discharges on biota and the population via drinking water and fish consumption must be weighed against the benefits which would accrue by reducing entrainment.

3. Means of treating the cooling tower blowdown and other chemical wastes should be included as an integral part of the design and operation of the closed-cycle, mechanical draft cooling towers. Such treatment is necessary since concentrations of zinc will exceed recommended levels and phosphates will not be removed as recommended by the Lake Michigan Enforcement Conference.

4. In order to avoid the use of chlorine or other damaging biocides, alternate means of cleaning the condenser and to control fouling should be investigated.

5. The present technical specifications do not clearly indicate a commitment to the intent of "low as practicable" since they do not require utilization of all radwaste systems to their design capacity.

6. Two radiological issues require further analyses and evaluation - transportation accidents and accidents involving reactor systems. These issues are common to all nuclear power plants, and it is appropriate that they be handled on a general basis. It is our understanding that the AEC is studying the probabilities and consequences of such accidents and will apply the study results to all licensed reactor facilities. EPA will work closely with the AEC in the conduct of this work.

RADIOLOGICAL ASPECTS

Transportation and Reactor Accidents

In its review of nuclear power plants, EPA has identified a need for additional information on two types of accidents which could result in radiation exposure to the public: 1) those involving transportation of spent fuel and radioactive wastes and 2) in-plant accidents. Since these accidents are common to all nuclear power plants, the environmental risk for each type of accident is amenable to a general analysis. Although the AEC has done considerable work for a number of years on the safety aspects of such accidents, we believe that a thorough analysis of the probabilities of occurrence and the expected consequences of such accidents would result in a better understanding of the environmental risks than a less-detailed examination of the questions on a case-by-case basis. For this reason, we have reached an understanding with the AEC that they will conduct such analyses with EPA participation concurrent with review of impact statements for individual facilities and will make the results available in the near future. We are taking this approach primarily because we believe that any changes in equipment or operating procedures for individ plants required as a result of the investigations could be included without appreciable change in the overall plant design. If major redesign of the plants to include engineering changes were expected or if an immediate publi or environmental risk were being taken while these two issues were being resolved, we would, of course, make our concerns known.

The statement concludes "...that the environmental risks due to postulated radiological accidents are exceedingly small and constitute a negligible hazard when compared to the benefits gained from the plant operation." This conclusion is based on the standard accident assumptions and guidance issued by the AEC for light-water-cooled reactors as a proposed amendment to Appendix D of 10 CFR, Part 50 on December 1, 1971. EPA commented on this proposed amendment in a letter to the Commission on January 13, 1972. These comments essentially raised the necessity for a detailed discussion of the technical bases of the assumptions involved in determining the various classes of accidents and expected consequences. We believe that the general analysis mentioned above will be adequate to resolve these points and that the AEC will apply the results to all licensed facilities.

Radioactive Waste Management

We have evaluated the capability of the existing radwaste systems to provide effluent control on an interim basis and the modified systems (to be installed in March 1973) to provide such control over the life of the plant. The modification of the systems by the addition of two evaporators and the increase in gas holdup capacity will provide the capability for minimum practicable releases of radioactive effluents.

Pending installation and operation of the modified systems, however, the existing liquid and gaseous waste treatment systems appear capable of restricting radioactive discharges to levels well below the limits specified in 10 CFR, Part 20, Appendix B, Table II. For that reason, they should be acceptable on an interim basis. Also, if properly utilized, the existing liquid waste disposal system with its 200,000 gallon storage capacity and demineralizers should be able to reduce radioactive effluents to levels substantially below the estimated discharge quantities (115 Ci/year) presented in Table III-6 of the environmental statement. For example, the AEC analyses indicate that if only 80% of the dirty waste (and none of the steam generator blowdown waste) is treated by demineralization, the discharge will be within 10% of 10 CFR, Part 20 limits (57 Ci/year). As indicated in the FSAR and the environmental statement, however, it is possible for the steam generator blowdown to be treated by the clean waste demineralizers. It appears to us that compliance with 10 CFR, Part 50.36a would necessitate treatment of the blowdown by demineralization whenever there is radioactive contamination on the secondary side of the steam generators. Thus, if all the dirty waste and the steam generator blowdown were treated by demineralizati‹ the releases of liquid radwaste prior to the operation of the modified systems could be limited to approximately 22 Ci/year, of which 17 Ci/year will be ^{99}Mo. We strongly encourage utilization of the entire capability of the existing (and future modified) systems to minimize releases of radioactive effluents to the environment. Without such utilization, the releases from this plant cannot be considered "low as practicable."

The present 30 day gaseous waste holdup system can reduce the release of reactor coolant off-gases to small fractions of 10 CFR, Part 20, Appendix B, Table II, levels and the modified 60 day holdup system will provide "as low as practicable releases." The release of radioiodine from the Palisades plant, however, cannot be construed to be minimal. According to the environmental statement, "...the addition of charcoal adsorbers in gas vent lines...would substantially reduce the gaseous radioactive iodine released to the environment. These charcoal adsorbers are used in most modern PWR facilities." We concur with the above AEC conclusion and recommend that iodine control systems be provided for this plant.

The environmental statement did not discuss either release of tritium or the effects of tritium recycle, which will occur once the modified radwaste system is in operation. Details of the public health significance of recycle of tritiated liquids should be presented in the final statement including: 1) the plant capability for storage of recycled liquids, 2) the calculated equilibrium concentrations of tritium, 3) the conditions under which tritiated water will have to be released and the expected concentrations and volumes to be released under the indicated conditions, 4) the dose consequence to the public as a result of these releases, and 5) the ultimate disposition of the tritiated water in the plant at the end of plant life.

The environmental statement did not address the possibility of the discharge of tritium to Lake Michigan. Apparently, the AEC assumes that, if all clean and dirty wastes are recycled, such releases will not be necessary. The applicant has stated, however, that tritiated liquids will be recycled or shipped off-site under "normal conditions" - defined as operation without detectable steam generator tube leakage. Thus, it appears that, under some circumstances, tritium may be released. Since the tritium concentrations will equilibrate at a higher level , with recycle than without and since there will be substantially less dilution water for any released tritiated waste with closed-cycle cooling, releases to Lake Michigan may have a public health significance relative to drinking water consumption. Therefore, we recommend that the final statement clearly define the expected impact of tritium.

NON-RADIOLOGICAL ASPECTS

Thermal Effects

The proposed once-through cooling system is not in accord with the recommendations of the Lake Michigan Enforcement Conference as approved in the "Summary of Conference" issued by the EPA Administrator on May 14, 1971. (These recommendations are listed in Appendix I). Thus, we concur with the addition of a mechanical draft, closed-cycle cooling system by December 31, 1973, and will accept the interim use of the once-through system.

Although operation of Palisades Nuclear Plant with once-through cooling is to be terminated by November 1973, the environmental statement did not adequately address the effects of the interim operation. For example, no rigorous analysis was provided for determining the temperature distribution in Lake Michigan that would arise from the discharge of the once-through cooling system. The statement did provide a qualitative description of plume behavior and a rough quantitative analysis of the plume area related to given isotherms. These analyses, however, are too limited to enable full evaluation of the thermal effects arising from the operation. Some specific deficiencies are:

1. The isotherm plots were not supported by adequate quantitative analyses.

2. The quantitative analysis, based on a study done for the Point Beach plant, omits important information on the assumptions, procedures, and diffuser specifications. Also, the analysis does not indicate the applicability of the Point Beach data to the situation at Palisades.

Recent research and data indicate that in the winter months a thermal barrier (thermal bar) forms off-shore in Lake Michigan. Although the hydrodynamic characteristics of this barrier are not yet understood fully, there is reason to believe that it may prevent the exchange of heat and pollutants between the shallow near-shore water and the deeper off-shore water. If this occurs, pollutants and waste heat from the Palisades plant and other sources will be confined to a smaller volume of lake water. This could lead to a greater accumulation of pollutants than would occur during the summer months when the thermal bar is not present. The final impact statement should address in more detail the potential problems associated with the thermal bar.

Biological Effects

The environmental statement indicates that there will not be a significant impact from once-through cooling. This conclusion is apparently based on the assumption that if there is no data indicating damage then there will be no damage. We cannot agree witn this assumption. Furthermore, since fish larvae and many other important components of the aquatic community have not been adequately sampled in the area, it is not clear how the AEC can conclude that there will not be ecological damage in the future. In the opinion of EPA, current information indicates that the once-through cooling system will result in a significant environmental impact.

The significance of entrainment on zooplankton is under considerable debate at the present time. It is not justified, however, to dismiss these effects as insignificant. The statement de-emphasizes the potential impact on zooplankton from passage through the condenser cooling system, apparently because they generally exhibit a high rate of regeneration. Although it is recognized that the populations of some zooplankton species can recover in a few days and that dead zooplankton do provide a food source for some aquatic organisms, EPA expects that the killing and subsequent discharge of 1,100 pounds per day of zooplankton will produce significant changes in the biota of the receiving waters.

According to the environmental statement, operation of Palisades should have no impact on lake trout since these fish occur largely in deep water. This conclusion. however, is not supported by data from the Bureau of Sport Fisheries and Wildlife, which indicates that lake trout spawn in large numbers along the entire southeastern shore of Lake Michigan. In addition, gravid and ripe trout have been caught in three and five fathoms near the intake and discharge points from the Palisades power plant. The final statement should provide additional information on the anticipated impact of plant operation on lake trout. Furthermore, perch and other desirable game fish will be attracted to the thermal plume in the winter. This exposure could affect the life and reproductive cycles of certain species.

For example, studies at EPA's National Water Quality Laboratory in Duluth, Minnesota, indicated that the reproductive success of perch is roughly halved if the perch are maintained at 43°F rather than 39°F for specified periods. Without thermal discharges, the ambient water temperature at the Palisades site will be 39°F or less throughout most of the winter season. The environmental statement indicates that with intake water temperatures of 37°F the 5°F excess temperature isotherm will cover approximately 165 acres. This large area could provide a habitat for a significant number of perch. The effect this exposure will have on the reproductive capacity of perch has not been addressed in the environmental statement.

Furthermore, the statement addresses the response of adult fish to thermal stress but does not discuss the thermal sensitivity of fish during migrations, particularly larvae and juveniles. Similarly, with regard to the coho salmon, the statement indicates that although the thermal plume will probably periodically block the entrance to the Black River with "near lethal" temperature levels, the impact is "...not expected to be major." The only support provided for this conclusion is that more salmon return to spawning areas than are necessary to maintain hatcheries. Successful spawning is influenced by many factors (e.g., temperature, toxic elements, disease), not just numbers of fish. The final statement should reassess the thermal impact of the plant discharges on Lake Michigan fish.

The environmental statement does not adequately support the contention that "The likelihood of a significant cold kill at the Palisades facility is small..." It is possible that some species of fish may exhibit high mortalities for sudden temperature decreases that are substantially less than the 30°F specified in the statement. If this occurs, the potential extent of the fish kill could be significant. The final statement should indicate the species likely to be killed by various temperature decreases, estimate the extent of the fish kill that will result, and predict the effect the kill will have on the total species population. In addition, the final statement should discuss the possible sub-lethal effects of rapid temperature decreases; for example, the changes in the predator/prey relationships that might occur due to temperature shock.

Although the environmental statement discusses the intake structure and indicates intake velocities of approximately 0.5 to 0.6 feet per second (fps) insufficient detailed information is provided on the design and operational characteristics of the intake system to determine the degree to which fish and other aquatic biota will be entrained. For example, the statement should include a discussion that compares the extent and effects of entrainment at various operational flow rates, such as 405,000 gpm (once-through), 73,640 gpm (closed-cycle service water plus dilution flow), and 13,640 gpm (closed-cycle service water only). In addition, any factors which might increase the populations of fish and other biota in the vicinity of the intake should be discussed. For instance, on occasion there will be some recirculation of heated water from the discharge; this is likely to occur when the discharge plume has a negative buoyancy. This increase in the amount of warm water near the intake structure will attract fish and, as a result, the likelihood of entrainment will increase.

Chlorination

Chlorine is expected to be utilized as a biocide with once-through cooling as well as in the modified closed-cycle cooling system. The adverse effects of chlorine upon the aquatic biota in the vicinity of the plant are not adequately understood. Thus, recognizing that alternatives are available, EPA agrees with the conclusion in the environmental statement that the use of chlorine in power plants does not seem justified. The alternatives to the use of chlorine should be discussed more fully and the relative environmental effects compared in the final environmental statement.

If chlorination is the only practicable alternative, however, the amount used should be controlled so that the concentration of residual chlorine in the receiving waters is within the limits recommended by EPA's National Water Quality Laboratory. (These recommendations and their bases are presented in Appendix II to this report.)

Such control, especially critical during the winter months, could be accomplished by dechlorination with sulfur dioxide or by other suitable means, and by correlating chlorination periods with high wave conditions. Furthermore, it is desirable to eliminate the possibility of synergistic effects of chlorination and cold shock by proper timing of chlorination so as not to coincide with rapid plant shutdowns.

Effects of Closed-Cycle Cooling System

The closed-cycle mechanical draft cooling system, which is scheduled for completion by November 1973, will bring the Palisades plant into compliance with the recommendations of the Lake Michigan Enforcement Conference. We are in agreement with the commitment of the applicant to adopt cooling towers and commend the AEC for accepting this plan. We believe, however, that although the draft statement correctly assesses the off-site effects from icing and fogging as being negligible, the statement over estimates the adverse environmental effects from cooling tower drift and blowdown. The potential damage to local vegetation from tower drift is discussed in the statement for drift loss rates of 20 gpm and 820 gpm. It should be emphasized that 20 gpm is probably the more reasonable value and assessment of drift effects should be based on this figure.

Although the statement deals with effects of various chemicals on vegetation, it does not predict the amount of chemical deposition to be expected over a given area. The statement, "Uncertainties...make it impossible to evaluate the extent of damage on the terrestrial ecology from cooling towers," is a fair assessment of the potential problem. Unfortunately, this statement is not consistent with the comment that the, "Operation of the Palisades plant with proposed mechanical draft cooling towers...will have a significant adverse effect...on terrestrial biota..." There is insufficient information provided to justify this conclusion.

Calculations show that the expected average annual evaporation would be about 6,000 gpm with a maximum of 9,200 gpm (compared with 12,300 gpm in the statement) and that blowdown, based on a concentration factor of 10, would average about 650 gpm with a maximum of 1,000 gpm (compared with the 1,320 gpm in the statement). Furthermore, cycles providing concentration factors greater than 10 would result in reductions in blowdown volume. Thus, we believe that the potential effects of blowdown will not be as great as indicated in the statement because the plant will discharge smaller volumes than assumed and additional reductions in volumes and concentrations are possible.

The applicant has proposed diluting the blowdown flow with 60,000 gpm to reduce the discharge temperature to 5°F above ambient. If the blowdown were discharged through a diffuser, it may be feasible to reduce the flow to less than 60,000 gpm and thereby limit entrainment damage to organisms. Although the dilution flow will cause a greater impact on the biotic community because of increased entrainment, it may be necessary in order to avoid undesirably high concentrations of radioactive and chemical wastes in the discharge.

As the AEC has concluded, the discharge of blowdown from the cooling towers would have an adverse effect on the aquatic community. Since blowdown treatment processes are technically and economically feasible, EPA recommends that these processes be used at the Palisades plant. Furthermore, blowdown treatment should be considered an integral part of cooling tower systems.

It is noted that the state of Michigan and the Lake Michigan Enforcement Conference have embarked on a program to reduce phosphorus discharge to the Lake Michigan Basin by 80% (see Appendix I). The Michigan Water Resource Commission indicates that it will require new users of state waters to "...utilize such technology and processes that are known..." to control phosphorus. Treatment systems are available to reduce phosphorus below 4 mg/l. In addition, the Michigan Water Quality Standard for zinc, as approved by EPA, is 1/10 of the 96 hour tolerance limit median (TLM). The information cited in the statement makes it apparent that this water quality standard may be violated by the proposed zinc discharge if blowdown treatment is not utilized.

ECOLOGICAL STUDIES AND MONITORING

We agree with the comment in the statement that the preoperational study of benthic organisms and fish fauna is inadequately designed and excludes the most significant aquatic communities during some of the critical periods of the year.

The aquatic ecological program should be modified to include: 1) plankton studies designed to determine the effect of entrainment; 2) close examinations of egg ratios to determine if regeneration does occur as rapidly as the environmental statement assumes; 3) fish population studies (adults, juveniles, and larvae) in the area during all seasons of the year; 4) surveys to determine the absence of fish larvae conducted prior to chlorination in the spring and summer; and 5) monitoring for E. Coli contamination from the septic disposal system. The studies should include the shoreline area an appropriate distance north and south of the plant, and should be designed so that thermal plume effects can be correlated with the factors of the environment being studied.

ALTERNATIVES

Generally, the various project alternatives regarding cooling systems, radioactive waste treatement, chemical waste treatment, and sanitary waste treatment were not adequately discussed. The discussion of cooling system alternatives should include greater detail on: 1) natural draft cooling towers, 2) diffuser systems (with and without the dilution water), 3) spray cooling devices, 4) modification of the discharge structure to provide a velocity greater than the planned 2 ft/sec, and 5) reduction in power to minimize effects of entrainment and heat until the closed-cycle system is operational.

The discussion of the waste treatment alternatives should be expanded to include possible means of eliminating atmospheric releases from the blowdown flash tank, treatment of the laundry waste to condition them for treatment by demineralization and/or evaporation (such as by charcoal beds, antifoaming additives, etc.), and alternatives for reducing iodine releases from the plant ventilation systems. The discussion of possible means for treating the chemical wastes and the laundry waste should be expanded to include greater detail of the processes, expected results, and costs.

COST-BENEFIT

The power output is the principal benefit of the Palisades plant. The value of this output should exceed the costs, including environmental costs but, unfortunately, this value is not presented in the statement.

Environmental costs for only two alternatives are presented. These are for the once-through cooling system initially proposed with discharge to the shoreline of Lake Michigan and the closed-cycle, mechanical draft cooling system. We suggest that other alternative system effects deserve evaluation. Natural draft cooling towers and once-through discharge with diffuser pipes are in this category. It should be demonstrated, as is the purpose of a cost-benefit review, that the proposed action has clear advantages over the obvious alternatives.

The environmental costs of other plant system alternatives such as mechanical cleaning of the condenser, blowdown treatment, and charcoal adsorbers should be evaluated.

The statement presents data indicating the need for electricity in terms of use projections. An attempt should be made to substantiate these projections. It is stated that a 7% growth rate is projected for the future although a 6% growth rate is observed for the past. Several plants are being proposed by the applicant and associated utilities to meet this projection. The role for Palisades as part of a program to meet realistic projections should be defined.

The following suggestions should be incorporated in the cost-benefit analyses in the final environmental statement:

1. Taxes may be considered to be roughly the cost of services provided by the various levels of government and, therefore, part

of the price of the electricity sold and should not be counted again.

2. The cost-benefit analysis should include the affected area that a power plant services. The impacts should be evaluated in the context of the totality of industry and the population projected for the area.

3. The costs cited are based on rough estimates. The 0.1 mill/kwh increase in consumer cost cited (on page 201) appears to be valid. All costs, however, should be reduced to mill/kwh at the busbar and at the consumer level so the true implications of these costs will be evident. Also, a breakdown of the estimated cooling tower operating expenses (4.2 million dollars per year) should be presented.

SITE SELECTION

The site selection apparently was not made in consideration of minimizing ecological damage. For this reason, the applicant is encouraged to take all necessary steps to stabilize the dunes and avoid losing more of this valuable land. The stabilization will protect against the "sanding in" of support facilities which is so common in cases where complexes have been constructed without appropriate consideration of the impact on the ecology of the site. A vigorous revegetation program, utilizing only indigenous and native plant material should be pursued in much greater detail and scope than that indicated (p.32).

The problem caused by additional population and development in the area is not a direct result of the Palisades plant. Nevertheless, to protect the quality environment that exists in Van Buren County, it would be beneficial for Consumers Power Company as a regional power supplier, to join municipal, state and Federal agencies in developing a land and water plan based on land capabilities in the area. This plan should be designed to achieve a balance between population, land-use and resources of the region, which will permit high standards of living and a quality environment.

ADDITIONAL COMMENTS

During our review, we noted that in certain instances the statement does not present sufficient information to substantiate the conclusions presented. While much of the individual details may not be of major importance in evaluating the environmental impact of Palisades, the cumulative effect could be significant. Therefore, it would be useful in determining the impact of the plant if the following information were included in the final statement:

1. Efforts to minimize future construction activities which will result in creation of air particulates, including elimination of open burning of debris by utilizing land fill techniques.
2. Procedures for the storage and handling of hazardous materials, including petroleum products, ammonia and hydrazine.
3. Evaluations of the emission of air pollutants relative to state and local requirements from auxiliary boilers, heaters, incinerators, concrete batching plants, and diesel generators.
4. Methods of solid waste disposal including: 1) HEPA filters, 2) debris and fish retained by or impinged on the traveling screens in the cooling systems, and 3) septic tank sludges.
5. The influence of the lake and land breeze on dispersion of effluents.
6. Assumptions and their bases for the estimated releases of gaseous and liquid waste discharges.

7. Evaluation of the gaseous radioactive waste releases from the auxiliary building.

8. Bases for the indicated technical specification limit of 0.8 Ci/yr for releases of ^{131}I.

9. Provisions for collecting, monitoring, and treating the secondary system leakage.

10. Provisions for monitoring effluents from the recently modified blowdown tank vent and an evaluation of the minimum detectable sensitivities of gaseous effluent monitors (μCi/sec discharge rate) for noble gases and halogens.

11. **Declaration** of the applicant's intent to treat steam generator blowdown in the waste evaporators and of the capacity of the evaporators.

12. The environmental consequences and radiological safety implications of a recurrence of the intake crib failure.

13. Expansion of the discussion of radiological doses to include: 1) dose estimates from direct radiation exposure from plant components; 2) methods of quantifying exposures to persons using ~~the visitor center~~, beaches, ~~and~~ the lake within the exclusion area; and 3) details of the assumptions used in evaluating doses (such as reconcentration and occupancy factors).

APPENDIX I

LAKE MICHIGAN ENFORCEMENT CONFERENCE RECOMMENDATIONS

In order to protect Lake Michigan, the following controls for waste heat discharges are concurred in by the Conferees representing Indiana, Michigan, Wisconsin, and the Environmental Protection Agency. Municipal waste and water treatment plants, and vessels are exempted from these recommendations.

I. Applicable to all waste heat discharges except as noted above:

1. At any time, and at a maximum distance of 1,000 feet from a fixed point adjacent to the discharge (agreed upon by the state and Federal regulatory agencies), the receiving water temperature shall not be more than 3°F above the existing natural temperature, nor shall the maximum temperature exceed those listed below, whichever is lower:

	Surface 3 Feet
January	45
February	45
March	45
April	55
May	60
June	70
July	80
August	80
September	80
October	65
November	60
December	60

2. Water intake shall be designed and located to minimize entrainment and damage to desirable aquatic organisms. Requirements may vary depending upon local situations; but, in general, intakes are to have minimum water velocity, shall not be influenced by warmer discharge waters, and shall not be in spawning or nursery areas of important fishes. Water velocity at screens and other exclusion devices shall also be at a minimum.
3. Discharge shall be such that geographic areas affected by thermal plumes do not overlap or intersect. Plumes shall not affect fish spawning and nursery areas, nor touch the lake bottom.
4. Each discharger shall complete preliminary plans for appropriate facilities by December 31, 1971, final plans by June 30, 1972, and place such facilities in operation by December 31, 1973; however, in cases where natural draft towers are needed, this date shall be December 31, 1974.
5. All facilities discharging more than a daily average of 0.5 billion BTU/hour of waste heat shall continuously record intake and discharge temperature and flow and make those records available to regulatory agencies upon request.

II. Applicable to all new waste heat discharges exceeding a daily average of 0.5 billion BTU/hour, except as noted above, which have not begun operation as of March 1, 1971, and which plan to use Lake Michigan waters for cooling.

1. Cooling water discharges shall be limited to the amount essential for blowdown in the operation of a closed-cycle cooling facility.

2. Plants not in operation as of March 1, 1971, will be allowed to go into operation provided they are committed to a closed-cycle cooling system construction schedule approved by the state regulatory agency and EPA.

   In all cases, construction of closed-cycle system and associated intake and discharge facilities shall be completed by December 31, 1973, for all other types of closed-cycle systems.

III. The states agree to file with EPA within six months a plant by plant program identifying corrective actions for the modification of intake faciliitcs, including power plants, municipal, and industrial users, to minimize the entrainment and damage to desirable aquatic organisms.

IV. The Conferees agree that there should not be a proliferation of new power plants on Lake Michigan, and that in addition to the above controls, limitations should be placed on large volume heated water discharges by requiring closed-cycle cooling systems, using cooling towers or alternative cooling systems on all new power plants.

Appendix II

CHLORINE RECOMMENDATIONS AND THEIR BASES

Table 1

Recommended Total Residual Chlorine in Receiving Waters for the Protection of Freshwater Aquatic Life

Type of Criteria	Recommendation for Total Residual Chlorine	Level of Protection
Continuous	0.01 mg/liter	This level would probably not protect trout reproduction, some important fish food organisms, and could be partially lethal to sensitive life stages of sensitive fish species.
Continuous	0.002 mg/liter	This level should protect most aquatic organisms.
Intermittent	A. 0.1 mg/liter not to exceed 30 minutes per day. B. 0.05 mg/liter not to exceed 2 hours per day.	These levels should not result in significant kills of aquatic organisms or adversely affect the aquatic ecology.

(The above recommendations require the use of the amperometric titration method that is among the most accurate for the determination of free or combined available chlorine in clean water. The method is largely unaffected by the presence of common oxidizing agents, temperature variations, and turbidity and color, which interfere with the accuracy of the other methods. Simpler methods, such as orthotoludine, are best suited for the routine measurement of total residual chlorine but are commonly affected by the above interferences and provide appreciably lower values than actually occur (Standard Methods, 1971). These colorimetric methods may provide a measure as low as 10% or less than the real level depending upon interferences.)

Table 2

Summary of Results of Brief Exposures of Fish to Total Residual Chlorine

Species	Effect Endpoint	Time	Residual Chlorine Concentration[a] mg/liter	Reference
misc.	initial kill	15 min	0.28	Truchan, 1971
misc.	erratic swimming	6 min	0.09	Truchan, 1971
trout fry	lethal	instantly	0.3	Coventry, et al., 1935
chinook salmon	first death	2.2 hrs	0.25	Holland, et al., 1968
white sucker	lethal	30-60 min	1.0	Fobes, 1972
brook trout	median mortality	90 min	0.5	Pyle, 1960
smallmouth bass	median mortality	15 hours	0.5	Pyle, 1960
rainbow trout	slight avoidance	10 min	0.001	Sprague & Drury, 1969
rainbow trout	lethal	2 hrs	0.3	Taylor & James, 1928
fingerling rainbow trout	lethal	4-5 hrs	0.25	Taylor & James, 1928
fathead minnows	TL50[b]	1 hr	0.79	Arthur, 1972
fathead minnows	TL50	12 hrs	0.26	Arthur, 1972
yellow perch	TL50	1 hr	0.88	Arthur, 1972
yellow perch	TL50	12 hrs	0.494	Arthur, 1972
largemouth bass	TL50	1 hr	>0.74	Arthur, 1972
largemouth bass	TL50[b]	12 hrs	0.365	Arthur, 1972
brook trout	mean survival time	8.7 hrs	0.35	Dandy, 1967
brook trout	mean survival time	14.1 hrs	0.10	Dandy, 1967
brook trout	mean survival time	20.9 hrs	0.05	Dandy, 1967
brook trout	mean survival time	24 hrs	0.005	Dandy, 1967

a. All concentrations are measured data

b. TL50 maximum tolerance limit

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:
PWR-ER

March 22, 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of March 3, 1972, requesting the comments of the Federal Power Commission on the Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consumers Power Company, Inc. for the Palisades Nuclear Generating Plant, prepared by the Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission, dated February 29, 1972.

The Federal Power Commission has previously commented on the need for the Palisades Nuclear Generating Plant in its letter dated October 22, 1971. These comments were included in a Bureau of Power staff report made in response to the AEC's letter dated October 8, 1971, requesting review and comment on the Consumers Power Company's application for interim authorization to operate the Palisades Plant at 60 percent of rated power. Also, FPC staff commented further on the 60 percent power level in a letter dated March 8, 1972, from T. A. Phillips to W. B. McCool in reply to Mr. McCool's letter of March 6, 1972, requesting specific information related to Palisades Plant and area power supply.

It is noted that the basic data included in the capacity-demand-reserve margin evaluation made by the FPC Bureau of Power staff in its October 1971 report is that used in Table I-3 of the Draft Detailed Statement which indicates a reserve margin for the Michigan Pool of 12.2 percent without the Palisades unit and 19.2 percent with that unit operating at a 700 megawatt electrical level. The data included in the table is still current except that the 789 megawatt electrical Monroe No. 2 fossil-fueled unit then expected to be in commercial operation in the spring 1972 and included as a firm resource is now not expected to be in commercial operation until May 1972. This additional delay, together with other factors in adjoining areas discussed below in the light of the Michigan Pool's stated 17 percent reserve margin criterion, places even greater emphasis on the need for the Palisades unit than that discussed on page 7 of the Draft Detailed Statement.

Mr. Lester Rogers

The Consumers Power Company has stated that it has thus far been unable to obtain any firm power purchase contracts for the summer 1972 load period except for the 200 megawatts shown for the Michigan Pool from the Ontario Hydro system. In this regard, and with reference to the situation within the East Central Area Regional Reliability Council (ECAR) as summarized for the summer of 1972 in Table I-4 of the Draft Detailed Statement, it should be noted that the 18 percent regional reserve shown includes not only the Palisades unit at 700 megawatts and the 789-megawatt Monroe No. 2 unit heretofore discussed, but also four other large fossil-fueled units not yet in operation, but currently expected to come into operation in the April-August 1972 period. These units and their sizes are: Mill Creek No. 1 - 321 megawatts, Stuart No. 3 - 610 megawatts, Eastlake No. 5 - 625 megawatts and Amos No. 2 - 800 megawatts.

The 1972 summer situation in the adjoining MAIN Regional Reliability Council area (Mid-America Interpool Network) has deteriorated from that shown in Table I-4 and also in the FPC Bureau of Power staff report transmitted to Chairman Schlesinger by Chairman Nassikas with his letter dated October 15, 1971. The 34,562 megawatts of planned capability originally shown has been reduced by 250 megawatts (reduced from 1,688 megawatts of non-firm purchases to 1,438 megawatts) because of changed conditions on the supplier's system. Of greater relative importance, however, is the magnitude of the generation, nuclear and fossil fueled, included in the above planned capability that is not yet in commercial operation, and which may make no contribution toward meeting the 1972 summer peak demands. Such nuclear units and their sizes are: Quad Cities No. 1 - 809 megawatts, Quad Cities No. 2 - 809 megawatts, Zion No. 1 - 1,050 megawatts, and Point Beach No. 2 - 497 megawatts. Also, a further erosion of planned resources of approximately 350 megawatts is involved in the environmental restrictions limiting the full output of the Dresden Plant.

While the delays in bringing fossil-fueled plants into commercial operation have not been as long as those currently experienced with nuclear plants, a delay of a few months can be critical in many instances. Large fossil-fueled units, initially scheduled for early spring 1972 operation, and included in the above generating resources, have experienced delays of up to four months. Such plants, not yet in commercial operation and now scheduled for May or June operation include: Cayuga No. 2 - 500 megawatts, Edwards No. 3 - 350 megawatts, Coffeen No. 2 - 600 megawatts, Powerton No. 5 - 840 megawatts, Neal No. 2 - 321 megawatts, Labadie No. 3 - 555 megawatts and New Madrid No. 1 - 600 megawatts. There is a likelihood that the MAIN region's

Mr. Lester Rogers

reserve margin levels for this period will be lower than desirable, hence the ECAR utilities cannot expect any firm power aid from the area. Similar problems exist with the utilities in the regional council areas to the south and east of the ECAR area.

It is noted that the transmission line additions to the existing bulk power system necessary to integrate the Palisades Plant into the existing system were relatively minimal and are complete.

Very truly yours,

T. A. Phillips
T. A. Phillips
Chief, Bureau of Power

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

APR 7 1972

Dear Mr. Muntzing:

This is in response to Mr. Rogers' letter of March 3, 1972, requesting our comments on the Atomic Energy Commission's draft detailed statement, dated February 29, 1972, on environmental considerations for Palisades Nuclear Generating Plant, Van Buren County, Michigan.

General

Our concerns for the adverse environmental impacts of this plant have been greatly reduced as a result of several major modifications in gaseous and liquid radwaste systems, and the decision to install cooling towers.

It appears that the AEC has expended considerable effort to assess the adequacy of the applicant's studies and to point out the inadequacies in the draft environmental statement. Inadequacies in assessing environmental impacts were acknowledged throughout the statement, but were critically evaluated beginning on page 131. We assume that inadequacies pointed out in the statement by AEC will also become AEC's requirements; therefore, we have generally not commented on them.

Site Selection

The various site selection studies described in this section are based primarily on economic considerations. We are cognizant of the greater emphasis now being placed on non-economic factors than at the time these studies were made. However, the assessment of environmental considerations is conspicuously absent from any of the studies described in this section.

Historic Significance

It does not appear that the existing plant should directly affect any existing or proposed unit of the National Park System, nor any site eligible for registration as a national historic, natural or environmental education landmark; however, the final statement should contain evidence of consultation with the State Historic Preservation Officer concerning the effects of the power station on places on or being considered for nomination to the National Register of Historic Places. He is the Director, Department of Natural Resources, Stevens T. Mason Building, Lansing, Michigan 48926.

Transmission Lines

We think that the applicant should conduct normal inspection of the right-of-way for the transmission line by plane, helicopter or on foot, thus eliminating the need to keep the entire right-of-way cut back in wooded areas. Clearing should be limited to only permit access of maintenance vehicles, and to keep the line free from intrusion of timber which would interfere with the safe operation of the line.

Effluent Systems

According to the report, debris and small fish removed from the trash racks and traveling screens in the water intake system will be disposed of as solid waste. However, the method of solid waste disposal is not explained, nor is an estimate of the quantity of solid waste involved given for other than radioactive wastes. We think these data should be included in the final environmental statement.

Radioactive Waste

According to the statement, all solid radioactive waste will be packaged and shipped to a licensed burial ground in accordance with AEC and DOT regulations. We think the location of burial site and the agency licensing it should be included in the final environmental statement.

Controls to Reduce or Limit Environmental Impacts

We suggest that the applicant consult with State and local authorities on constructing nature trails, landscaping and replanting dune grasses where necessary to restore the site, and disposing of solid waste collected on the water intake screens. It appears that the applicant is taking appropriate action in regard to most of these items; however, we think consultation with appropriate entities would assure adequate protection and utilization of the environment at minimum cost.

Biological Impacts

The term "sterile zone" used on page 106 is misleading since it includes a zone extending approximately one mile offshore. Figures V-4 and V-5 show that there is some benthic productivity in this wave-washed zone. Various studies also indicate that this zone is highly important to certain fish and other aquatic life during some portion of their life cycle. We suggest the term "less productive" be substituted for "sterile".

We remain concerned that the project may have significant adverse effects on aquatic life in Lake Michigan. Significant numbers of important sport and commercial fishes may become entrapped by the cooling system during the 42-month period prior to construction of cooling towers. Preoperational studies, with sampling done in May, June, August, and October revealed that the intake is located at a depth used extensively by many fishes. The area within the zone influenced by the thermal plume will act as an attractant for certain fish species, resulting in possible entrapment of considerable numbers in front of the screens. Although the intake velocity is about 0.5 or 0.6 feet per second, operating experience may show that additional screens around the intake are necessary for adequate protection of the fishery.

Accidents

The section on Environmental Impact of Postulated Plant Accidents gives an adequate evaluation of impacts resulting from postulated accidents through Class 8 for air borne emissions. However, the environmental effects of releases to water are lacking. Many of these accidents described in tables V-6, V-7, and V-8 could result in releases to the water and should be evaluated in detail.

We also think that Class 9 accidents resulting in both water and air releases should be described and the impact on human life and the remaining environment discussed as long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects on land and possibly throughout the entire Great Lakes and could persist for centuries.

Transportation of Nuclear Fuel and Solid Radioactive Waste

According to information given on page 165, about 9 truck-loads or 1 to 3 rail car loads of packaged solid radio-active wastes will be shipped from the plant site each year. Later subsections treat the probability of recurrence and the impact of accidents. We suggest that details concerning the procedures to be used when a spilled shipment occurs should also be given in this section.

Adverse Environmental Effects Which Cannot be Avoided

The statement is made on page 183 that no consumptive use of the lake water will result from once-through cooling. Although consumptive use of the cooling water is not apparent at the plant, a substantial amount of induced evaporation is involved and water is evaporated as a direct result of the plant. It is estimated that about 50 - 75% of the waste heat discharged in the cooling water is dissipated from the lake water surface through the evaporative process. Furthermore, table IX-2 shows that the consumptive use of water from the once-through operation is about 80% of that for the cooling tower systems; however, this estimate appears to be high.

Cost-Benefit Analysis

We continue to believe that environmental costs and benefits should be expressed in non-dollar quantitative terms. A table similar to IX-2 but with emphasis on environmental impacts is suggested for the final statement.

Recommendations

Since fish are expected to be attracted to the warm water plume, a shutdown, especially during the winter, would probably cause significant mortality during the period when the once-through method of cooling is used. Consequently, we recommend that all maintenance requiring shutdown be scheduled during times other than winter.

We hope these comments will be helpful as you prepare the final environmental statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. L. Manning Muntzing
Director of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (WS)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: 202-426-2262

13 APR 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of 3 March 1972 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning the environmental impact statement, environmental report and other pertinent papers on the Palisades Nuclear Generating Plant located in Van Buren County, Michigan.

The concerned operating administrations and staff of the Department of Transportation have reviewed all the material submitted.

Noted in the review of the Office of Hazardous Materials is the following:

> "We have no specific comments to offer on this report. We find no statement or information regarding the transport of radioactive material which are inconsistent with existing DOT or AEC regulatory requirement."

We have no further comments to offer on any of the material submitted and this Department has no objection to the issuance of a license for this facility.

The opportunity to review and comment on the Palisades Nuclear Generating Plant is appreciated.

Sincerely,

W. M. Benkert

W. M. BENKERT
Rear Admiral, U. S. Coast Guard
Chief, Office of Marine Environment
and Systems

STATE OF MICHIGAN

NATURAL RESOURCES COMMISSION
HARRY H. WHITELEY
Chairman
CARL T. JOHNSON
E. M. LAITALA
HILARY F. SNELL

WILLIAM G. MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T. MASON BUILDING, LANSING, MICHIGAN 48926

RALPH A. MAC MULLAN, Director

WATER RESOURCES COMMISSION
JOHN H. KITCHEL, M.D.
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JOHN P. WOODFORD
Vice Chairman
CHARLES D. HARRIS
JOHN E. VOGT
STANLEY QUACKENBUSH
ALVIN R. BALDEN
THOMAS F. JAMES

May 2, 1972

RECEIVED
MAY 8 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

Mr. Lester R. Rogers
U.S. Atomic Energy Commission
Division of Radiological and
Environmental Protection
Washington, D. C. 20545

Dear Mr. Rogers:

Enclosed is a copy of our staff comments on the Atomic Energy Commission's Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consumers Power Company, Inc., for the Palisades Nuclear Generating Plant.

Sincerely,

WATER RESOURCES COMMISSION

Ralph W. Purdy

Ralph W. Purdy
Executive Secretary

JGT/RWP/mf
cc: Mark Mason, Governor's Office
Tom Doyle, Fisheries Division
Roy Thoma, A.E.C.

Review of Atomic Energy Commission's Draft
Detailed Statement on the Environmental
Considerations Related to the proposed Issuance
of an Operating License to the Consumers
Power Company, Inc., for the Palisades
Nuclear Generating Plant

Issued February 29, 1972

Michigan Department of Natural Resources

Water Resources Commission
Bureau of Water Management

and

Fisheries Division

This review is limited to considerations of environmental impact on the aquatic resources of Lake Michigan in the vicinity of the Palisades Plant. The Michigan Water Resources Commission (MWRC) adopted Order of Determination No. 931 on October 27, 1966, setting forth the restrictions on this plant's discharge. On November 19, 1971, the MWRC established a thermal discharge standard (Paragraph A6) as an amendment to the Order of Determination No. 931 (order No. 1582). The Palisades discharge from the once-through cooling system as presented in the Atomic Energy Commission (AEC) review of radioactive and heat wastes will be within the limits imposed by the MWRC Orders but will not meet the Environmental Protection Agency's (EPA) recommended thermal discharge standards for Lake Michigan after December 31, 1972. The applicant is committed, prior to January 1, 1974, through an agreement with intervenors in the licensing procedure, to install and operate mechanical draft cooling towers. The effects of chemicals contained in the cooling tower blowdown discharge are generally covered by section six of the existing Order of Determination; however specific restriction may be necessary in the form of an amended order at a later date when the Company decides on the specific chemicals to be used within the towers.

The Consumers Power Company has also entered into an agreement with the intervenors to modify the liquid radioactivity waste system so that (except for laundry wastes) all liquids in the radioactivity waste system will be recycled back into the cooling systems and radioactive material removed in processing the liquids will be converted to solid form for removal from the plant. This modified system will reduce the liquid waste radioactivity to levels at or below the AEC limits given in the appendix to Title 10, Code of Federal Regulations, Part 50 (10 CFR 50). The effluent from the laundry will be collected in the laundry drain, filtered and discharged via the circulating water discharge canal if the radioactivity is not more than 2.5×10^{-8} μ Ci/cc on an annual basis. If the activity is more than this value, the waste will be processed in the secondary waste section. The volume of laundry wastes is very small (38,000 gallons/year). If this effluent were recycled after filtering, the plant would have no planned radioactivity releases to the lake.

During winter, it is expected that the thermal plume will develop a density underflow within the thermal bar of the onshore zone. This underflow will be from one to five degrees Fahrenheit (F.) warmer than temperatures typically found there. As the plume mixes with the colder onshore water, it will reach maximum density of 39.2° F. and sink to the bottom coming into contact with the maximum density water lying in the bottom zone of the main body of the lake. This may in effect disrupt the thermal bar phenomenon resulting in a significant increase in the onshore temperature regimen. In the movement of this water away from the point of discharge by alongshore current flow, there is the potential for incorporating a substantial amount of deeper lake water into the plume since the deeper lake water will be of the same density. This could affect a volume of water completely disproportionate to the volume of the plant discharge. The effects of this density underflow are unknown, but both faunal and floral inhabitants of this zone will be subjected to increased metabolic rates. The spawning and development of whitefish, ciscoes, and lake trout could be adversely affected. Rapid changes in current pattern could result in some thermal shock to organisms previously under the influence of the density underflow. Additional emphasis should be placed on investigating the magnitude of the discharge plume.

The diagrammatic representations of summer stratification (page 26) and density plumes (page 50) should only be interpreted to be average conditions. Strong offshore winds in summer can cause upwelling of a cold water mass which may remain for many days; likewise, persistent onshore winds can hold the surface warmed water within the onshore zone. Either condition can create isothermal conditions from top to bottom in the water column.

Representation of the various density plumes (surface, interflow and underflow) may not be representative of the condition near the cooling water intake. There will be a volume of water equivalent to approximately 1800 acre-feet moving into the intake every day. The intake has only 20 feet of water over it, and we expect that virtually the entire water column in the near vicinity will be moved to its entrance. In the case where the discharge plume flows over the intake, recirculation of cooling water and excessive build-up of temperature may occur.

The location of the intake structure is 3300 feet offshore in 26 feet of water. The intake crib is approximately 6 feet off the bottom and has an intake velocity of 0.5 to 0.6 feet per second (fps). Any fish that pass through the crib structure into the intake pipe (velocity 9.0 fps) will be unable to escape damage or death on the traveling screens and trash racks. The spacing of intake crib bars will not exclude even large fish, and we understand that fish as large as 24 inches in length have been taken off the screens. It is anticipated that at times large numbers of juvenile salmonids and other species will occur in the vicinity of the intake and be pumped to the screens. If this happens, they will be impinged on the screens and lost. If this loss is significant, it will be necessary to promptly modify the intake to eliminate this problem.

The intake structure is kept ice free in the winter by recirculating approximately 17,000 gallons per minute (gpm) of the condenser cooling water from pumps in the discharge channel. This recirculated warm water discharge could act as an attractant resulting in increased intake fish mortalities. No discussion is given to possible adverse effects in winter from this recirculated warm water.

All conclusions with regard to chlorine toxicity are based on data derived from studies in which a continuous exposure regime was employed. No work has been done on the toxic effect of intermittent exposures of chlorine. Until such data is available it appears impossible to predict the biological effects of a monthly one-hour exposure to 0.5 mg/l total chlorine. It is also equally difficult to predict what deleterious effects will occur from a daily one hour exposure to a 0.022 mg/l concentration possible in the diluted cooling tower blowdown.

Chlorine present in the once-through cooling water discharge will be mainly free chlorine because of the low chlorine demand and low organic matter present in the intake water. Based on our field observations, the free chlorine will dissipate at a more rapid rate than the heat from the condenser cooling water. The predictions of the areal extent of the chlorine (p. 197) based on the heat dissipation of the thermal plume will therefore be much greater than would actually occur. This area should be evaluated fully in the environmental monitoring program.

Another concern is the discharge of chemicals in the cooling tower blowdown. If phosphorus is used in the system the amount present in the cooling tower blowdown could be equivalent to the amount of phosphorus discharged by a municipality with a population of 74,500 people. This figure does not include the phosphorus possibly leaching back into the lake from the cooling tower drift. The volume of water lost through drift is predicted not to exceed 820 gpm and estimated to be 20 gpm on the average. If the actual volumes are near the maximum, a 60 percent higher phosphorus contribution to the lake area is possible. This substantial increase in phosphorus would serve to emphasize the need to include drift eliminators in the tower design. The MWRC has a policy of requiring all municipal waste treatment facilities to remove 80 percent of the phosphorus in their waste. Since the phosphorus contribution from the cooling tower blowdown will be far in excess of the minimal requirements it appears that the company could be required to treat this waste in a similar manner. The MWRC will make the final determination as to whether the company will be required to treat the cooling tower blowdown for removal of phosphorus.

We are also concerned with the predicted high concentrations of metals that could also be used in the towers and would be discharged to the lake in the cooling tower blowdown. These metal concentrations may have to be reduced either by treatment or dilution to non-toxic levels.

A 30 percent loss of zooplankton through entrainment in the once-through system is presumed not to have a significant impact on the ecosystem; however, this conclusion is based on speculation with precise predictions not possible with available information. Although the dead organisms are not lost to the food chain, the continual supply of ready food organisms could significantly change the community structure in the area of the plant. We hope that the full impact on the inshore biota resulting from this continuous killing of one-third of the zooplankton will be thoroughly evaluated.

There have been repeated statements in the descriptive material that lake trout spawning and/or egg incubation occurs only at depths of greater than 200 feet. Historically, lake trout in the Great Lakes occupied many diverse habitat types. As man has preyed upon them taking those forms most readily available, the shallow water spawners and anadromous types have been eliminated by overfishing leaving only the deep spawners to be exploited. The stocks presently being reintroduced are the progeny of hatchery broodfish derived from Wisconsin and Lake Superior lean (shallow water) forms, and these fish can be expected to spawn in a fairly broad range of depths from shallow to moderate. Canadian fisheries workers for a number of years in the 1950's took eggs from an anadromous run of lake trout into the Montreal River whose spawning depth could hardly be more than twenty to thirty feet.

The statement on page 117 concerning whitefish, "This species is close to the southern limit of its distribtuion at the Palisades site, and depends upon exceptionally cold winters for successful reproduction in the southern basin of Lake Michigan", is in error. This results from a misinterpretation of Lawler's[1] paper on whitefish which particularly emphasizes data from Lake Erie. The range of whitefish extends to the southern tip of Lake Michigan and along the southern edge of Lake Erie as presented on Figure 1, Appendix V-2 of the review. Lawler related a several degree increase in the average temperature of Lake Erie to decreased whitefish spawning success. He postulates that because of the average temperature increase in recent decades whitefish only spawn successfully in Lake Erie during exceptionally cold winters. Lake Erie's shallow eutrophic western basin can hardly be compared to Lake Michigan's deep oligotrophic southern basin. We find no data to indicate the same sort of temperature increase in Lake Michigan. If, in fact, the surface water temperature has increased, whitefish could still find suitable spawning temperatures at lower depths.

In Appendix V-2, there is considerable discussion of the whitefishes (whitefish, lake herring, and chubs) but only with reference to the endangered species Coregonus alpenae is over-fishing mentioned as a factor in their decline. With the advent of nylon twine after World War II and an uncontrolled entry of fishermen into the commercial harvest, the take increased to the point of collapse. During 1966, for example, the amount of net set in Lake Michigan by commercial fishermen totaled 28,000 miles. Now that commercial fishing is regulated and lamprey populations are being controlled to very low levels, we can predict a substantial future increase in the populations of whitefish. We do not know how the species' composition will compare with that which previously existed. Spawning and survival of fry and juveniles of any of these species cannot be discounted. Any significant disruption of onshore habitat conditions by man's activities

[1]Lawler, G.H., "Fluctuations in the Success of Year-Classes of Whitefish Populations with Special Reference to Lake Erie", J. Fish. Res. Bd. Canada 22 (?)

might prevent their successful re-establishment.

The discussion of coho salmon (page 121) being affected by temperature elevation and, "the impact is not expected to be major, particularly since more salmon generally return to parent streams than are necessary to supply hatcheries with eggs," displays a lack of knowledge of the Michigan Department of Natural Resources Fisheries Division fish stocking, and particularly, the salmon programs, which have no dependence on natural propagation. We are not in the business of stocking fish so they mature and return to hatcheries to provide an egg intake. The whole idea is to provide a surplus for harvest and any predation (e.g., losses through the cooling water intake, or loss of habitat caused by the thermal plume or chlorination) results in an economic loss to the state which cannot just be written off. The estimates of damage (pages 138 and 150) do not adequately represent those values. Calculations based upon the entire lake volume and area are totally inappropriate. The inshore waters are many times more productive than the pelagic or open water zone, and they represent only four percent of the lake volume. Synoptic trawl surveys of the former Bureau of Commercial Fisheries in Green Bay (which would be more indicative of inshore productivity) provide catch data ranging from 32 to 36 pounds/acre which represents only a portion of the standing crop. Established fish values when lost through pollutional activities range from $1/pound for non-game fish to $10/pound for game fish. Schooling fish species are quite liable to be destroyed in disproportionately great numbers when compared to average population densities. We recommend damages be recomputed to reflect these considerations.

In summary, we recommend that the following considerations be included in the complete analysis of the environmental impact of the Palisades Nuclear Power Plant:

1. Examine the possibility of including laundry wastes into the radioactive waste treatment system.

2. Evaluate the effects of the density underflow aspect of the discharge plume on the thermal bar and the potential for incorporating the deeper lake water into the plume when the plume is under the influence of strong alongshore current flow.

3. Undertake a year-round surveillance of the loss of fish in the intake screens and consider the potential adverse effects of recirculating condenser cooling water to keep the intake ice free.

4. Determine the detrimental effects of intermittent chlorine slug exposures rather than drawing conclusions based on continuous exposure data. In assessing the areal extent of the chlorine realize that the decreasing concentration of the chlorine is not solely through dilution of the cooling water with lake water.

5. Evaluate the potential eutrophication of the lake possible from phosphorus carried in the cooling tower blowdown and in the airborne drift. Also decrease the drift by the inclusion of drift eliminators in the design and construction of the towers.

6. Investigate treatment processes to remove the phosphorus and zinc contributed by the cooling tower blowdown and drift.

7. Thoroughly evaluate the adverse ecological effects of continually killing 1/3 of the zooplankton in the intake water and resultant changes in the aquatic floral and faunal community structure in the area of the Palisades plant.

8. An evaluation of the potential adverse effects on lake trout recognizing that the trout currently being stocked by the Fisheries Division will spawn in shallow to moderate depths rather than depths greater than 200 feet as indicated in the review.

9. Recognize the potential for significant disruption of the effort to re-establish whitefish in Lake Michigan.

10. In assessing the costs of fish losses, the higher values that are applied to fish lost through pollutional activities should be applied.

11. Assessment of the impact of the plant's discharge on the heat budget and productivity of the lake should be compared to the volume and area of the nearshore waters rather than the total lake volume and area.

12. We do generally concur with the AEC's staff analysis and comparison of the environmental costs of each type of cooling system and specifically with the statement that "there does not appear to be sufficient ecological justification for the additional resource investment (and subsequent increased cost to the consumer) necessary to provide cooling towers".

Lake Michigan
Thermal Pollution
Consumers Power Co.; Palisades Plant
Filed under: Thermal Pollution

May 2, 1972

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T. MASON BUILDING, LANSING, MICHIGAN 48926

RALPH A. MAC MULLAN, Director

May 19, 1972

RECEIVED MAY 31 1972

Dr. Mary Jane Oestmann
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Dr. Oestmann:

As far as can be determined at this time, the Palisades Nuclear Generating Plant in Van Buren County, Michigan, will not adversely affect known historical or archaeological resources of the State of Michigan.

Sincerely,

Samuel A. Milstein

Samuel A. Milstein
Deputy Director - Recreation
and
State Liaison Officer for
Historic Preservation

cc: Dr. W. J. Ross

MICHIGAN THE GREAT LAKE STATE

'ILLIAM G. MILLIKEN, Governor

,URICE S. REIZEN, M.D., Director

STATE OF MICHIGAN
DEPARTMENT OF PUBLIC HEALTH
3500 N. LOGAN, LANSING, MICHIGAN 48914

May 4, 1972

Mr. Lester R. Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

Following are comments from the Michigan Department of Public Health, Division of Radiological Health, regarding the "Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consumers Power Company, Inc. for the Palisades Nuclear Generating Plant," Docket 50-255 by the U. S. Atomic Energy Commission, Division of Radiological & Environmental Protection issued February 29, 1972.

1. Figure III-13 Gaseous Effluent Flow Sheet shows 6 gaseous effluent systems, only one of which includes charcoal filter elements to remove halogens. It is possible that radioactive halogens may be in any of the six effluents and, in fact, the Consumers Power supplemental information report of November 3, 1971 specifically notes iodine release from the Auxiliary Building Vent. We recommend that charcoal filter systems be required for all gaseous effluent systems as noted on page 202 of the Statement.

2. The applicant has specified that potentially high activity radioactive gases are to be collected in the Waste Gas Surge Tank, compressed, and stored for decay in one of three Gas Decay Tanks. As an alternative to storage, they may be discharged directly through particulate filters to the Ventilation Stack. Three additional Gas Decay Tanks are to be installed in the future to allow a 60 day minimum holdup time rather than the 30 day minimum holdup time with three tanks. We recommend that the operating specifications for the plant be revised such that the company is required to hold these gases for the maximum possible decay time, rather than allowing discharge directly to the stack. Radioactive waste gas discharges will thus be maintained at the lowest possible level within the capabilities of the plant equipment.

3. The only potentially radioactive liquid effluent which is not routinely treated for removal of radioactivity before discharge is the Plant Laundry effluent. It is stated that contaminated clothing could be disposed of as solid waste instead of being laundered. We recommend that this be made a technical operating procedure for the plant to reduce even further this contributor to radioactive liquid effluent.

4. The applicant has alluded to the release of tritium in the gaseous effluent including the cooling tower, but has not specified the amount. These amounts should be provided on both an annual and a concentration basis.

We appreciate the opportunity to comment on the Statement and request that serious consideration be given to the implementation of our recommendations.

Sincerely,

Maurice S. Reizen, M.D.
Director

TOWNSHIP OF COVERT

VAN BUREN COUNTY

COVERT, MICHIGAN 49043

March 24, 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U.S. Atomic Energy Commission
Washington, D. C. 20545

Ref: Docket No. 50-255

Dear Mr. Rogers:

I have reviewed the Environmental Impact Documentation and find it most interesting. It would appear the Consumers Power Company has made the correct decision in building a nuclear plant in this area because of the cost and access of other types of fuel, and based on the knowledge gained at the Big Rock Nuclear Plant.

The plant site was an extremely good choice since it did not displace any year round homes, only several summer cottages. The replacing of the sand quarry operation with this beautiful plant has been most favorable to the appearance of the total area.

My greatest concern is the constructing of cooling towers. The fact that some 1,500,000 gallons of water will go into the air every 24 hours and that this could give us a build up of certain residue on the ground in the surrounding area. Increase in chlorine to Lake Michigan because of the blowdown needed to keep the towers functioning properly must be considered. The increase of fog, icing and even snowfall must be considered as potentially hazardous. The increase in cost to the user of electricity when it is questionable if the cure is any better than the supposed disease (thermol pollution of Lake Michigan). All these factors must be considered since the system originally planned did not have any of these factors.

It would appear that the towers should be de-activated in the winter months to conserve electricity and eliminate the amount of chemicals going into Lake Michigan through the tower blow down process.

Finally, it would appear that the plant should be allowed to operate at full power as soon as possible so that valuable data can be gathered and used in designing future plants for the entire country.

Many confusing questions are being raised. Only by actual operation can these doubts be substantiated so that we can all live in a safe and bountiful area of nuclear energy which promises to be perhaps one of the greatest assets from the development of the Atomic Bomb.

There are many other points I could touch on but it would make these comments to lengthy.

In closing I would like to state that this Community has not experienced any opposition to the Plant being located here. It has provided jobs during construction and now during operation to many people in the area. It has increased tax dollars to County and Township government and greatly benefitted the local school financial needs.

Sincerely,

Jerry Sarno

Jerry Sarno, Supervisor
Covert Township

JS:mk

R. C. Youngdahl
Senior Vice President

Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-0550

May 3, 1972

MAY 8 1972

Mr. R. C. DeYoung
Assistant Director for Pressurized
Water Reactors
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. DeYoung: Re: Docket No. 50-255

In response to your letter of April 21, 1972, I am enclosing three signed originals and 25 additional copies of Consumers Power Company's responses to agency comments on the Draft Environmental Statement for the Palisades Plant. We appreciate the opportunity to comment, and hope that the enclosed material will be of use to you.

Yours very truly,

R. C. Youngdahl

RCY/bbm

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of)
CONSUMERS POWER COMPANY) Docket No. 50-255
(Palisades Plant))

RESPONSE TO AGENCY COMMENTS

ON DRAFT ENVIRONMENTAL STATEMENT

On February 29, 1972, the AEC Staff issued its "Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to The Consumers Power Company, Inc., [sic] for the Palisades Nuclear Generating Plant, Docket No. 50-255" (hereinafter called the "Draft Detailed Statement"). Thereafter, on April 21, 1972, the Staff forwarded to the Applicant copies of comments on the Draft Detailed Statement received by the Staff from the Advisory Council on Historic Preservation, the Department of Agriculture, the Detroit District of the Corps of Engineers of the Department of the Army, the Department of Commerce, the Environmental Protection Agency, the Federal Power Commission, the Department of the Interior, the Department of Transportation, and the Township of Covert (Van Buren County, Michigan). The Applicant's review of the agency comments was requested.

Attached are the Applicant's responses to several of the agency comments. The Applicant has not attempted to respond to all of the comments, for various reasons. If additional information or response is desired as to any particular agency comment, a further response will be provided.

The attached responses in general cover only those areas where the Applicant believes that additional information or clarification might be useful for the drafting of the Final Detailed Statement.

CONSUMERS POWER COMPANY

By R. C. Youngdahl

R. C. Youngdahl
Senior Vice President

Sworn and subscribed to before me this 3rd day of May, 1972.

Helen R. Lehr

Helen R. Lehr
Notary Public, Jackson County, Michigan
My Commission Expires December 11, 1973

I. <u>DETROIT DISTRICT, CORPS OF ENGINEERS, DEPARTMENT OF THE ARMY</u>

COMMENT: "However, the Michigan Water Resources Commission has not yet certified the company's application for discharge permits nor has the concurrence of the Environmental Protection Agency been obtained."

RESPONSE: The above statement, while true, does not affect this proceeding. Under §21(b)(7) of the Federal Water Pollution Control Act, no Michigan Water Resources Commission certification is required for plant operation until April 3, 1973, which date is three years after the adoption of the Water Quality Improvement Act of 1970.

Further, there is no legal requirement that EPA concur in the granting of an operating license for the Palisades Plant, or in the proposed operation of the plant. If the portion of the comment referring to EPA refers only to the question of discharge permits under the so-called "Refuse Act," the Applicant has taken all action required of it under that act.

COMMENT: "EPA recommends that a blowdown treatment system be included as an integral part of the cooling tower design." (Cover letter, p. 1.) "Such treatment is necessary since concentration of zinc will exceed recommended levels and phosphates will not be removed as recommended by the Lake Michigan Enforcement Conference." (Comments, p. 1.) "Since blowdown treatment processes are technically and economically feasible, EPA recommends that these processes be used at the Palisades Plant." (Comments, p. 16.)

RESPONSE: While the technology does exist to treat water in the quantity and quality of the blowdown effluent, all available techniques would require significant amounts of additional chemicals or energy, or both, in turn creating additional effluent problems. Furthermore, none of these techniques is economically feasible.

The Applicant is investigating the possibility of eliminating the use of corrosion inhibitors in cooling tower water, to avoid discharging zinc and phosphate to the environment. The technical feasibility of doing so has been established, and an economic study is in progress.

II. ENVIRONMENTAL PROTECTION AGENCY

COMMENT: "The major impact of Palisades nuclear plant prior to December 31, 1973, when the mechanical draft cooling towers are to be operational, will result from thermal discharges. Although these discharges will exceed criteria recommended by the Lake Michigan Enforcement Conference, we accept interim operation of the Palisades plant using once-through cooling with the understanding that the proposed closed-cycle cooling system be installed in accordance with the agreed upon schedule."

RESPONSE: For clarification, it should be noted that the recommended "criteria" to which reference is made were expressly made inapplicable to new plants, such as the Palisades Plant, that are committed to an approved closed-cycle cooling system construction schedule. Item II.2 of the Lake Michigan Enforcement Conference Recommendations states that "Plants not in operation as of March 1, 1971 will be allowed to go into operation provided they are committed to a closed cycle cooling system construction schedule approved by the State regulatory agency and EPA. In all cases construction of closed cycle systems and associated intake and discharge facilities shall be completed by December 31, 1974 for facilities utilizing natural draft towers and December 31, 1973 for all other types of closed cycle systems."

The Applicant presumes that EPA has in mind the schedule agreed upon in the Applicant's Settlement Agreement with Intervenors in accepting interim operation of the Plant using once-through cooling.

II. ENVIRONMENTAL PROTECTION AGENCY (Contd)

COMMENT: "The most significant radiological impact due to routine operation of Palisades will be from radio-iodine discharges through plant ventilation systems. In order to achieve low as practicable iodine discharges, we recommend the installation of charcoal adsorbers for the plant ventilation systems." (Cover letter, p. 2; see also Comments, pp. 5-6) "[I]n the expected release of I-131, . . . the anticipated release of the Palisades plant is about 33 times that anticipated for [Calvert Cliffs, Point Beach and Turkey Point]. * * * It is also indicated on Table III-5 that the Technical Specifications will limit the release of I-131 to 0.8 Ci/yr, a value which is only about 25% of the anticipated release. It would be helpful if the draft statement would indicate in what manner this limitation would be achieved." (Attachment to comments of Department of Commerce, p. 2.)

RESPONSE: The AEC staff estimated the thyroid dose to a child from iodine due to ingestion of milk to be 1.3 mrem/yr (Reference: Table V-3 of the Draft Detailed Statement). This was based on an annual release of 3.27 Ci through the containment building exhaust and steam generator leakage (Reference: Table III-5 of the Draft Detailed Statement). The Applicant disagrees. The annual release of I-131 through the containment building exhaust and steam generator leakage should be 0.0001 Ci rather than 3.27 Ci. The Applicant estimates the inhalation dose to the thyroid from all iodine isotopes released during normal operation to be about 0.00009 mrem/yr. Theoretically, the ingestion dose to a child from the consumption of milk could be as high as 0.06 mrem/yr (assuming that the ingestion dose is a factor of 700 greater than the inhalation dose).

Both the AEC-calculated and the Applicant-calculated values are below the limits specified in proposed Appendix I to 10 CFR Part 50, however, and will thus be within the numerical guides for meeting the "as low as practicable" criterion. The Applicant therefore does not agree

RESPONSE (Contd)

that the backfitting of charcoal adsorbers to the Palisades Plant is necessary.

The Technical Specification limit for I-131 given in the Draft Detailed Statement as "0.8 Ci/yr" (Table III-5, fn) and referred to by the Commerce Department, is incorrect. The I-131 release limit derivable from the formula set forth in §3.9 of the Technical Specifications is 2.25 Ci/yr rather than 0.8 Ci/yr.

II. ENVIRONMENTAL PROTECTION AGENCY (Contd)

COMMENT: "Damage to aquatic organisms resulting from entrainment in the proposed 60,000 gpm blowdown dilution flow could be eliminated by discharging the blowdown without dilution. Since this would result in a proportional increase in concentration of radioactive and chemical waste discharge to Lake Michigan, the impact of these discharges on biota and the population via drinking water and fish consumption must be weighed against the benefits which would accrue by reducing entrainment." (Comments, p. 1.)

RESPONSE: Because of the need for reasonable operating flexibility, elimination of the blowdown dilution flow is not feasible. If the dilution flow were eliminated, the radiological release limit would be reduced to 0.26 Ci/yr* -- about 20 times lower than the limit stated in proposed Appendix I to 10 CFR Part 50.

* Calculated as follows, utilizing an MPC of 1×10^{-7} uCi/ml, which is commonly employed for unidentified mixtures of nuclides:

$$(10^{-6}\,\mathrm{Ci/uCi})(1 \times 10^{-7}\,\mathrm{uCi/ml})(3.786 \times 10^{3}\,\mathrm{ml/gal})(1320\,\mathrm{gpm})(5.25 \times 10^{5}\,\mathrm{min/yr}) = 0.26\,\mathrm{Ci/yr}$$

COMMENT: "In order to avoid the use of chlorine or other damaging biocides, alternate means of cleaning the condenser and to control fouling should be investigated." (Comments, p.2.)

RESPONSE: The available alternatives to chlorination include recirculating sponge balls, automatic brushes and manual brush cleaning.

Due to the number (about 28,000) and length (70 ft.) of the condenser tubes, manual brush cleaning is not practicable.

Automatic brushes are driven back and forth through the tubes by reversing the flow of water through the condenser. Accomplishing this would require extensive modification of piping already set in concrete. This alternative is therefore not practicable.

The use of recirculating sponge balls appears feasible, and Applicant intends to pursue the possibility of substituting this method of condenser cleaning for chlorination. At the present time, it is not clear that the use of sponge balls would be environmentally and economically preferable to chlorination. Their use would probably involve the discharge of significant amounts of shredded sponge to Lake Michigan. As the balls recirculate, they are worn down by abrasion until they are lost from the system. Even if strainers were installed on the tower blowdown, some of the particles removed from the sponge balls by abrasion would get out of the system via the blowdown.

Furthermore, the Applicant does not expect the consequences of chlorination of cooling tower water to be as severe as indicated in either the Draft Environmental Statement or the EPA comments. The Applicant believes that the chlorine discharges will be substantially less than estimated because the Applicant intends to secure the cooling tower blowdown for a period of time during and after chlorination. This

RESPONSE: (Contd)

will allow the available chlorine to be exposed to air and light as it passes through the towers, thus aiding its decomposition before discharge. The Applicant will be unable to specify the amount of reduction achievable by this means until it has actually operated the cooling towers and has determined (a) how long blowdown can be secured before there is an unacceptable buildup of chemical concentrations in the water, and (b) how rapidly the chlorine will decompose when recirculated through the tower.

COMMENT: "The present technical specifications do not clearly indicate a commitment to the intent of 'low as practicable' since they do not require utilization of all radwaste systems to their design capacity." (Comments, pp. 2, 5; see also Department of Commerce comments, p. 3 of attachment.)

RESPONSE: Section 3.9 of the Palisades Plant Technical Specifications governs the release of radioactive materials. The stated objective of the limits is to assure that levels of radioactive material in releases are kept as low as practicable. The Technical Specifications do not require full utilization of all radioactive waste processing equipment all of the time. Such a requirement would be impractical, because maintenance is necessary to assure optimism performance of the equipment.

Further, the Applicant expects to meet the release limits to be specified in Appendix I to 10 CFR Part 50.

COMMENT: "The environmental statement did not discuss either release of tritium or the effects of tritium recycle, which will occur once the modified radwaste system is in operation. Details of the public health significance of recycle of tritiated liquids should be presented in the final statement including: 1) the plant capability for storage of recycled liquids, 2) the calculated equilibrium concentration of tritium, 3) the conditions under which tritiated water will have to be released and the expected concentrations and volumes to be released under the indicated conditions, 4) the dose consequence to the public as a result of these releases, and 5) the ultimate disposition of the tritiated water in the plant at the end of plant life." (Comments, p. 6.)

RESPONSE: Southern Nuclear Engineering, Inc. has just completed a study for the Applicant to determine the potential tritium buildup in the reactor coolant grade water for the design life of the plant (40 years). It is predicted that in the event all reactor coolant grade water containing tritium is recycled over the 40-year lifetime of the plant, the tritium activity in the reactor coolant, primary system makeup tank, and the SIRW tank will be about 2.8 uci/cc. This value is based on the realistic assumption that the reactor coolant water will be mixed with the water in the spent fuel pool (21,389 ft^3), the SIRW tank (33,420 ft^3) and primary system makeup storage tank (26,736 ft^3) each time the plant is refueled. It is also calculated that the quantity of tritium that will be released to the environment through the containment building and spent fuel pool room exhaust system due to evaporation is as follows:

RESPONSE: (Contd)

Operation at Full Power (Years)	From the Containment Bldg (Ci/Yr)	From the Spent Fuel Pool (Ci/Yr)	Total Release (Ci/Yr)
5	2.7	3.1	5.8
10	6.3	10	16.3
15	10	19	29
20	13	27	40
25	16	34	50
30	20	41	61
35	23	49	72
40	25	55	80

NOTE: The tritium production rate, based on the escape of 1% of the fission product tritium through the fuel cladding plus activation-produced tritium, is 267 Ci/yr.

In the event tritium is released to the environment because of primary to secondary system leakage, the above concentration and quantities to be released with the gas will be reduced. The concentration released in the liquid during abnormal operation (steam generator leakage) will not exceed the concentration to be specified in Appendix I to 10 CFR Part 50.

The annual average concentration of tritium as water vapor in the gas release at the end of 40 years is calculated to be about 0.006% of MPC (10 CFR 20) at the site boundary. This value is based on an annual average X/Q of 4.6×10^{-6} sec/m^3 and the assumption that no deposition occurs between the plant and the site boundary.

The Applicant is not now committed to a specific method of disposal of tritiated water at the end of plant life. Several alternatives appear to be available. They include:

(1) Solidify and store either on-site or at an authorized burial site

RESPONSE: (Contd)

(2) Process tritiated liquid through a tritium concentrator and then solidify the concentrated tritiated water for storage. The Applicant is helping sponsor a program to investigate techniques for concentrating tritium.

(3) Store off-site in a liquid form.

COMMENT: "Recent research and data indicate that in the winter months a thermal barrier (thermal bar) forms off-shore in Lake Michigan. Although the hydrodynamic characteristics of this barrier are not yet understood fully, there is reason to believe that it may prevent the exchange of heat and pollutants between the shallow near-shore water and the deeper off-shore water. If this occurs, pollutants and waste heat from the Palisades plant and other sources will be confined to a smaller volume of lake water. This could lead to a greater accumulation of pollutants than would occur during the summer months when the thermal bar is not present. The final impact statement should address in more detail the potential problems associated with the thermal bar."

RESPONSE: The Applicant is not familiar with any evidence suggesting that pollutants accumulate in the inshore waters during the period of the so-called "thermal bar" or that if they do, that the thermal discharge from a power plant would accelerate pollution effects.

Dr. Pritchard of Johns Hopkins University testified at the Workshop Session for the Third Session of the Conference in the Matter of Pollution of Lake Michigan and its Tributary Basin in the States of Wisconsin, Illinois, Indiana, and Michigan (transcript P. 832) that "I do not consider the thermal bar, however, to be an actual barrier to mixing." He further stated that, based upon the physics of the phenomenon, and as verified by field studies in Lake Ontario, that (transcript P. 834) "The conditions which are associated with the thermal bar must set up a motion, and that motion, because it represents a change in velocity field at the thermal bar, must provide for an actual increase in the transport of material across the bar."

At the same meeting, Dr. John C. Ayers of the University of Michigan, commented that (transcript P. 1082) "As I see the inshore bar and have seen it for several years, Pritchard's computations of shear mixing along the bar are evident."

RESPONSE (Contd)

To provide a better understanding of the thermal bar phenomenon in Lake Michigan and its influence on near-shore limnological characteristics, the Applicant, in cooperation with American Electric Power Service Corporation and Northern Indiana Public Service Corporation, has sponsored a study of the thermal bar by The University of Michigan. The field work for this study was conducted in the spring of 1971. The project consisted basically of a series of multispectral aerial scans over a period of several weeks that observed the thermal bar along the eastern shore of Lake Michigan, from Muskegon, Michigan into Indiana. Water samples and other observations were taken periodically during the survey period to correlate water quality with recorded spectral differences. The study report is expected to be available by May 5, 1972 and copies will be furnished to the ASLB and the parties.

II. ENVIRONMENTAL PROTECTION AGENCY (Contd)

COMMENT: "The aquatic ecological program should be modified to include 1) plankton studies designed to determine the effect of entrainment; 2) close examinations of egg ratios to determine if regeneration does occur as rapidly as the environmental statement assumes; 3) fish population studies (adults, juveniles, and larvae) in the area during all seasons of the year; 4) surveys to determine the absence of fish larvae conducted prior to chlorination in the spring and summer; and 5) monitoring for E. Coli contamination from the septic disposal system. The studies should include the shoreline area an appropriate distance north and south of the plant, and should be designed so that thermal plume effects can be correlated with the factors of the environment being studied." (Comments, p. 18.)

RESPONSE: Plankton studies have been included in the aquatic ecological monitoring program to determine the effects of entrainment. They include monthly intake and discharge samples of plankton, with analyses to estimate zooplankton mortality and changes in primary productivity.

Detailed analysis of zooplankton and phytoplankton from ten sampling stations will be made for four separate sampling periods. Quantitative evaluation of plankton volumes will be determined at the same time for the 31 preoperational survey stations. These data, together with the intake and discharge samples, will provide a more direct measure of the significance of plant effects on plankton regeneration than would any attempt to examine "egg ratios."

In addition to the continuation of the preoperational fish sampling program, all of the various stages of fish life will be sampled by means of monthly trawling and seining during all seasons of the year.

Periodic attempts will be made to sample fish larvae in the influence of the plant discharge, and various surveys will be scheduled to detect direct effects of chlorination on aquatic life. Direct observations of fish behavior will be made during chlorination.

RESPONSE: (Contd)

It would be impractical to attempt to judge the performance of the septic disposal system by shoreline monitoring of E. Coli. Existing levels and variability of E. Coli in Lake Michigan would mask any possible effects from the plant system, the location of which is considered highly suitable for subsurface disposal systems of its size.

II. ENVIRONMENTAL PROTECTION AGENCY (Contd)

COMMENT: "The discussion of the waste treatment alternatives should be expanded to include possible means of . . . treatment of the laundry waste to condition them for treatment by demineralization and/or evaporation (such as by charcoal beds, anti-foaming additives, etc.) . . . . The discussion of possible means for treating . . . the laundry waste should be expanded to include greater detail of the processes, expected results, and costs." (Comments, p. 19.)

RESPONSE: The Applicant will continue to investigate alternatives for treatment of laundry waste to reduce radioactive liquid discharge.

Investigation to date has shown that it is not feasible to demineralize or evaporate laundry waste. Utilizing an off-site laundry service would reduce the discharge from the Palisades Plant, but would in all likelihood merely transfer the environmental impact to another location.

Treatment of the laundry waste by high-efficiency filtration is being investigated. A reverse osmosis filtration device is in the development stage. The Applicant will consider utilization of such a device if one of sufficient size and efficiency becomes commercially available.

R. C. Youngdahl
Senior Vice President

Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-0550

May 12, 1972

AEC DOCKET NO. 50-255 - PALISADES PLANT

RECEIVED MAY 15 1972

Mr. R. C. DeYoung
Assistant Director for Pressurized
Water Reactors
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. DeYoung:

We have reviewed the comments submitted on May 2, 1972 by the Michigan Department of Natural Resources relating to the Draft Detailed Statement for the Palisades Plant.

Most of the DNR comments concern matters already adequately covered by the Draft Statement, or matters on which we have no further information to offer.

Two items merit mention, however. Item 2 on page 5 of the DNR comments recommends an evaluation of "sinking plume" effects. We wish to point out that measurements of this nature are included as part of our environmental surveillance program.

Item 3 of the recommendations is based on a misconception regarding our intake design. The recirculating water line does not extend out into the Lake to the intake crib. Rather, the recirculation line pumps water from the discharge structure to the forebay at the Plant intake structure on the shoreline.

Thank you for the opportunity to respond to the DNR comments.

Yours very truly,

R C Youngdahl

RCY/bbm

Stephen H. Howell
Executive Manager of Electric Plant Projects

Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-0550

May 19, 1972

RECEIVED MAY 22 1972 U.S. ATOMIC ENERGY COMMISSION

AEC DOCKET NO. 50-255 - PALISADES PLANT

Mr. Daniel R. Muller, Assistant Director
For Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

We have received and reviewed the May 4, 1972 comments of the Michigan Department of Health (Division of Radiological Health) on the AEC Draft Detailed Statement for the Palisades Plant.

In our May 3, 1972 responses to agency comments, we covered the subjects of the four Health Department comments. We have two specific comments to add respecting Health Department comments 3 and 4.

In comment 3, it is recommended that contaminated clothing be disposed of offsite as solid waste instead of being laundered. This is of course feasible. For most operator functions, but not for maintenance functions, experience at Big Rock Point has shown that it is possible to use paper clothing that is disposed of after use. Regular protective clothing must be used for maintenance, however. On the basis of Big Rock Point experience, we estimate that the cost of disposing of all protective clothing rather than laundering it would be on the order of $40-50,000 per year at Palisades, including the cost of the clothing. Since radioactive effluent from laundry waste will meet proposed Appendix I to 10 CFR Part 50, we do not believe that there is a benefit to be gained which would warrant this cost. As noted in our prior comments, we are continuing to investigate other alternatives for reducing laundry waste radioactivity.

In response to the cooling tower reference in comment 4, we would like to supplement our May 3 response (pp. 10-11) by emphasizing that no tritium of plant origin will be added to the condenser cooling water cycle under either normal or abnormal operation.

Yours very truly,

Stephen H. Howell

SHH/bbm

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

OFFICE OF THE SECRETARY

WASHINGTON, D.C. 20201

50-255

JUN 12 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of March 3, 1972, wherein you requested comments on the draft environmental impact statement for the Palisades Nuclear Generating Plant, Consumers Power Company, Inc.

This Department has reviewed the health aspects of the above project as presented in the documents submitted. We offer no comments.

The opportunity to review this draft environmental impact statement is appreciated.

Sincerely yours,

Merlin K. DuVal M.D.

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs