Dr Morris

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of CONSUMERS POWER COMPANY (Midland Plant)	)))))	Docket No. 50-329 Docket No. 50-330

SUMMARY OF APPLICATION

October 30, 1970

TABLE OF CONTENTS

TABLE OF CONTENTS (Contd)

1.0 <u>INTRODUCTION</u>

This document, prepared and filed by Consumers Power Company (hereinafter sometimes called "applicant"), is a summary of the application filed by the Company for permits from the Atomic Energy Commission to construct a two unit nuclear power plant, on a site in Midland Township, Midland County, Michigan.

This document has been prepared in accordance with the provisions of 10 CFR, Part 2, Appendix A, Section II (e), as a summary of the Company's *application, including a summary description of the reactors, an evaluation of the considerations important to safety and a comparison of the proposed reactor design with the design of the reactors previously approved or built. To assist interested members of the public in understanding the complex technical material dealt with in this report, applicant has endeavored to use nontechnical language whenever possible.

To enhance the usefulness of this summary, applicant has included within it summaries of reports rendered by the Advisory Committee on Reactor Safeguards on the application pursuant to Section 29 of the Atomic Energy Act of 1954 as amended (42 USC Section 2039), and information incorporated in the docket in accordance with the National Environmental Policy Act of 1969, P.L. 91-190.

*The application and other pertinent documents currently in the record of this proceeding may be examined at the Grace Dow Memorial Library, 1710 W St Andrews Road, Midland, Michigan.

In addition to a summary of the application, this document contains a summary of applicant's program to consult with and obtain comments of interested Federal, state and local government officials in planning for the Midland Plant. In cases where applicant is required to obtain state and local approvals or permits in connection with the design or construction of the plant, or approvals from other Federal agencies, this summary describes the status of applicant's efforts to obtain such approvals.

Some of the information in this summary with regard to applicant's programs to consult with or obtain regulatory approvals of government agencies other than AEC is not in the record of this proceeding, or is based on more recent information. Applicant is prepared to establish such information by appropriate evidence at the hearing to whatever extent is determined to be appropriate in the course of this proceeding.

Applicant is prepared also to substantiate any other information summarized in this summary, or in the application as amended, by appropriate testimony in the hearing as may be appropriate for determination of any issues before the Atomic Safety and Licensing Board.

As set forth more fully in the ensuing sections of this summary, two nuclear units and appurtenant facilities, which have been designated as the Midland Plant (hereinafter sometimes called "the plant"), will occupy an 1190.38-acre site on the southerly shore of the Tittabawassee River opposite the industrial complex of The Dow Chemical Company at Midland. The units are presently scheduled to begin commercial operation in November 1974 and November 1975. Both units are conventional pressurized water reactors (PWR) designed together to generate about 1,300,000 kW of electricity. They are similar to many other pressurized water reactors which are in operation or under construction.

The plant will provide a base load electrical capacity which will be needed by the applicant and by the Michigan Power Pool to meet projected electricity requirements. The plant will also provide the process steam requirements of The Dow Chemical Company.

The plant is being designed and all planning is being carried out, with preservation and enhancement of the environment as important considerations. Assurance of safety has been of paramount consideration in selecting a design for the Midland Plant. The plant is being designed to keep radioactivity in plant effluents at the lowest practicable level and far below concentrations which independent government authorities find to be satisfactory. The small quantities of radioactive waste materials in liquid effluents will be well below concentrations which such authorities find to be satisfactory for drinking water. The cooling pond will protect against discharge of deleterious heat. All aspects of plant design, construction and operation will be carried out in accordance with applicable requirements of Federal, state and local government agencies.

One important environmental consideration in planning for the plant is the fact that operation of the plant will enable the Michigan Power Pool to shut down a number of older plants which consume fossil fuel. The new plant will also enable The Dow Chemical Company to shut down all of its existing steam plants which now burn fossil fuel.

As stated in the September 23, 1970 letter from the Federal Power Commission to the Atomic Energy Commission concerning the applicant's proposed Midland Plant:

> "Under the prevailing fuels situation, if the Company had considered a fossil-fueled plant as a substitute for the two Midland nuclear units, the plant would of necessity have been a coal-fired plant and, as such, its operation would have added particulate and gaseous pollutants to the atmosphere. The nonpolluting characteristics of nuclear generation can be expected to aid in maintaining air quality in the Company's service area."

Construction of additional electric generating capacity to meet projected increased requirements is a responsibility of Consumers Power Company as a public utility under the laws of the State of Michigan. Fulfillment of that responsibility is essential to the health and economic well-being of the citizens of Michigan and surrounding areas, as well as to the national defense. The Midland Plant is important in meeting these goals and applicant believes it will do so in a manner which is consistent with the highest environmental and ecological considerations.

2.0 BACKGROUND

2.1 Consumers Power Company

Applicant is a combination electric and natural gas utility serving more than 1,000,000 electric customers in the lower peninsula of Michigan. Applicant's electric service area covers approximately 27,100 square miles and contains a population of approximately 3,200,000. Principal cities receiving electrical service are Battle Creek, Bay City, Flint, Grand Rapids, Jackson, Kalamazoo, Midland, Muskegon, Pontiac and Saginaw. Industries in the territory served by applicant include automobile and automobile equipment, primary metals, chemicals, fabricated metal products, pharmaceuticals, machinery, oil refining, paper and paper products, food products and a diversified list of other industries.

The maximum net demonstrated capability of applicant's interconnected system, which system is shown in Appendix B, Figure 2, exceeds 3,700,000 kilowatts. The net maximum demand on the interconnected system was 3,377,275 kilowatts on December 15, 1969. In order to serve this load, applicant presently operates ten fossil fuel steam-electric plants, one nuclear steam-electric plant, fourteen hydroelectric plants, seven gas turbine peaking plants and one internal combustion plant. In addition, applicant and The Detroit Edison Company are the principal members of the Michigan Power Pool. Applicant is directly or indirectly interconnected with other utilities in Michigan, Indiana, Illinois and Ohio as a member of the MIIO group. The MIIO group consists in varying capacities of applicant, The Detroit Edison Company, Indiana & Michigan Electric Company, The Toledo Edison Company, Northern Indiana Public Service Company, Ohio Power Company and Commonwealth

Edison Company. There are several agreements among various of the companies in regard to operations, facilities and coordination. The agreements provide for the construction of interconnection facilities and for the terms and conditions on which power is interchanged. Applicant is interconnected through The Detroit Edison Company with The Hydro-Electric Power Commission of Ontario. Applicant is also a party to the East Central Area Reliability Coordination Agreement along with eighteen other parties. The purpose of this agreement is to augment reliability of the parties' bulk power supply through coordination of planning and operation of generation and transmission facilities. Applicant sells electric energy at wholesale to a number of municipalities, rural electric cooperatives and invester-owned public utilities.

Applicant and The Detroit Edison Company operate under an agreement which provides for pooled operation of their systems, coordination of systems planning, design and construction, the rendering of mutual assistance during emergencies, and the effecting of maximum economy of production in providing the electric power requirements of each system. Each system is thus dependent on the other system, as well as on its own, having new generation available on schedule. In addition, both The Detroit Edison Company and applicant must be concerned with the construction programs of utilities in neighboring states and such utilities in turn are concerned with and affected by their construction programs. To this end, the Michigan Power Pool has made interconnection with utilities in Indiana and Ohio and is coordinating its construction and operation through the MIIO group and the East Central Area Reliability Agreement.

The advantage of interconnection and coordinated construction and operation is that savings can be made in investment for reserve capacity; additional energy supplies can be obtained during time of emergency; at times, more economical energy can be obtained from neighboring systems; advantage can be taken of the fact that peak loads occur at different times on different systems; required maintenance can be carried out at more convenient times and economies of scale can result because of the ability to construct larger plants.

2.2 Applicant's Participation in the Development of Nuclear Power

Applicant owns and operates the Big Rock Point Nuclear Plant located near Charlevoix, Michigan. This plant is a boiling water reactor with a nameplate capacity of 75 MWe. Applicant received a construction permit for the Big Rock Point Plant dated May 31, 1960, a provisional operating license, dated August 30, 1962, permitting operation at power levels up to 157 MW_t, and a final operating license dated May 1, 1964, permitting operation at power levels up to 240 MW_t. Since startup in 1962, the Big Rock Point Plant has produced net in excess of 2,423,164 MWhe. This reactor was one of the early privately owned reactors for the production of electric power.

Applicant has constructed the Palisades Nuclear Plant located near South Haven, Michigan and is presently engaged in a public hearing on its application for an operating license for that plant. The Palisades Plant is designed to have an initial capacity of about 700 MWe with an ultimate capacity of about 821 MWe.

Applicant has been a pioneer in the use of nuclear power for electric generation and has participated in the design, construction and operation of nuclear plants for over ten years. It has a large and experienced body of personnel that have operated nuclear plants and have overseen the design and construction of nuclear plants.

2.3 Need for This Plant

The demands on applicant's system have doubled over the last ten years and are expected to more than double over the next ten. It is necessary for an electric utility to forecast its demand well in advance and to start planning and building new generation long before it is needed. It is estimated that applicant's peak loads will be 5,130 megawatts in the winter of 1974-75 and 5,600 megawatts in the winter of 1975-76. In order to meet this projected demand and to provide the 17-18* percent reserve margin which applicant considers desirable, applicant is planning additions to its present net demonstrated capability of 3,731 megawatts. These additions to capacity, in addition to the Palisades Plant, include an 1,800 megawatt pumped storage project for operation in 1973 which is jointly owned with The Detroit Edison Company; the two-unit 1,300 megawatt Midland Plant for operation of one unit in 1974 and the other in 1975, and two approximately 660 megawatt oil-fired intermediate load units for operation, respectively, in 1975 and 1976. Of the units planned for this time period, only the Palisades and Midland Plants are base load units, ie, designed to operate

*This 17-18 percent margin is an increase from the 15.5 percent margin previously considered desirable by Consumers Power Company. The increase results from the increased outage problems experienced by large generating units and difficulties of scheduling maintenance of such large units with only a 15.5 percent reserve margin.

more than 50 percent of the time. Both the pumped storage plant and the oil-fired units are designed to operate less than 50 percent of the time to meet various levels of peak demand. Both Midland units are needed on schedule if applicant's system is to maintain an adequate margin of reserves to assure reliable electric service to the State of Michigan.

While the Federal Power Commission's (FPC) comment to the AEC on the environmental aspects of the Midland Plant, dated September 23, 1970, does not reflect the latest data available to applicant or the current construction schedules available to applicant, FPC's assessment of the need for the Midland Plant is accurate:

> ". . ., the load supply situations in the Pool . . . should be judged in the light of recent experience with availability of large new generating units. During the period of October 1973 and February 1975, the Pool is planning to place on the line two fossil-fueld steam units with capacities in excess of 650 megawatts and a nuclear unit with a capacity in excess of 1,000 megawatts [in addition to the Midland Plant]. The indicated reserve margins assume availability of these units as planned. The recent history of large fossil and nuclear steam generating units, however, reveals that during the first few years of initial operation, the availability of large units can be highly uncertain. On this account, we feel that the indicated reserve margins of the Michigan Power Pool are not excessive and that prudence dictates the need of the Midland Units 1 and 2 as a bulwark against the possible unavailability of existing capacity."

In addition, the Federal Power Commission stated:

> "It is evident, therefore, that if Consumers Power is to meet expected loads . . ., reliance cannot be placed on import of required firm power in lieu of construction of Midland Nuclear Units 1 and 2."

The Federal Power Commission, also, recognized the unavailability of practical fossil-fired and hydroelectric alternatives to the Midland Plant.

The Midland Plant is, therefore, necessary to meet peak loads and to help assure a reliable supply of electric power. In addition, the plant is necessary to assure continued growth and development in the State of Michigan. The addition of the Midland Plant will enable applicant to provide electricity for industrial, commercial and residential development and will aid the applicant in maintaining a rate structure which is competitive with the cost of energy in other states. This in turn will aid the state in attracting and retaining industry. Also, low cost process steam will enable Dow to maintain its growth in Michigan. In addition, the availability of electric power in Michigan will enable applicant to aid utilities in other states during short-term emergencies. Operation of the Midland Plant will enable the Michigan Power Pool and Dow Chemical Company to retire older, less efficient fossil-fueled units with resulting economies and with resulting benefits to the environment. For all of these many reasons, the Midland Plant is a desirable and necessary addition to the applicant's system and to the electric supply system of the State of Michigan.

2.4 Considerations Entering Into Selection of the Plant

The Midland Plant features, including the location, grew out of a mutual need of The Dow Chemical Company and Consumers Power Company to meet their respective and increasing energy demands. Dow, which had traditionally generated all of its own process steam and electrical requirements at Midland with dual-purpose generating plants, was becoming less competitive for the manufacture of energy intensive products due to prohibitive fossil-fuel cost escalation. In order to take advantage of the fuel economies of a large nuclear plant but lacking the projected load to utilize the full capacity of such a plant, Dow requested Consumers Power Company to consider an allocation of Dow's process steam requirements as part of a Consumers Power Company facility. Consumers Power Company's system energy capacity forecast for 1974-75 indicated a need for increased generating capacity in the Midland-Bay City-Saginaw load center area. It was thus natural for Dow and Consumers Power Company to look toward a dual-purpose nuclear facility to meet their respective energy needs.

Inherent in the considerations given to the general features of the plant, was the long-time Dow experience with steam extraction which in turn gave promise of minimizing the plant waste heat. This feature gave rise to a plant efficiency similar to the most efficient fossil-fueled plants, and thus appreciably reduced the normal nuclear plant heat rejection.

The air pollution resulting from the current Dow generating plants will be eliminated. The use of standard components to enhance reliability was a requisite in the Midland Plant.

By considering the mutually compatible energy needs of Dow and Consumers Power Company, a nuclear-fueled steam extraction plant using a cooling pond designed to dissipate the total plant heat rejection is the most appropriate means of meeting these needs.

2.5 Process Steam To Be Supplied to Dow Chemical Company

The steam to The Dow Chemical Company will be supplied from the secondary side of tertiary system heat exchangers. A complete system of shell and tube evaporators will be installed for both the high-pressure and low-pressure steam supplies. The design flows to Dow are 400,000 lb/hr of the high-pressure and 3,650,000 lb/hr of the low-pressure steam.

The feedwater in the tertiary loop from which the process steam will be produced comes from Lake Huron. At any given time, the feedwater stream will consist of condensate return from Dow, and makeup water from the lake which is demineralized before being transmitted to applicant.

It is a criterion for the process steam that no radioactivity be added to the feedwater by the process of transforming it to steam in the tertiary system heat exchangers. To meet this criterion, the process steam will be separated from the reactor coolant water, which contains radioactivity, by two barriers: a steam generator and a tertiary system heat exchanger. In addition, the radioactivity in the process steam will be compared with the radioactivity in the makeup water. If the activity level in the steam indicates radioactivity leakage to the steam from the secondary system, the flow of process steam from the specific tertiary heat exchanger producing the steam will be terminated.

3.0 THE EVOLUTION OF DESIGN OF THE MIDLAND FACILITY

As suggested in Appendix A, 10 CFR Part 2, this portion of the applicant's summary is a "discussion of the evolution of the proposed reactor design, including associated engineered safety features, from the design of reactors which have previously been approved or built." As will appear from this discussion and the information set forth in other sections of this summary, the principal design features of the Midland Plant are based upon designs incorporated in earlier plants.*

3.1 Reactors

3.1.1 Shippingport - The First Commercial PWR

The first nuclear reactor constructed to generate electricity for commercial uses was Shippingport. Design of the plant began in 195_ and it first produced electricity for commercial use in 1957.

Shippingport is a four-loop PWR. Its initial core was about 6 feet high and 6-1/2 feet in diameter, was composed of zirconium-clad fuel plates and rods and produced approximately 335 MW_t. It employed 32 cruciform rods for control and was contained in a reactor vessel approximately 32 feet tall and 9 feet in diameter. Each coolant loop contained one reactor coolant pump and one steam generator. This reactor operated at a pressure of approximately 2000 psia and an average temperature of 520°F and produced sufficient steam at approximately 600 psia to generate approximately 90 MWe.

*For a comparison of important parameters for the Midland Plant with those for a number of other PWR, see Section 9.0 and Appendix A of this summary.

The Shippingport reactor at the time of its design was a reasonable extension of known reactor technology which had been obtained principally from the Navy nuclear program. The plant demonstrated that commercial generation of electricity by nuclear power plants was feasible and it pointed the way for the design of future PWR. Specifically, it showed that:

1. A light water-cooled and moderated nuclear reactor fueled with slightly enriched uranium could be used to reliably produce steam to generate electricity.
2. Normal central station-type turbine generator equipment could be coupled with a nuclear reactor.
3. Fuel element burnups of 3000 to 4000 MWD/MTU were obtainable.
4. The use of concrete for shielding was practical.
5. The use of 600 psi saturated steam in a turbine generator was practical.

3.1.2 Indian Point I - An Early Large Commercial PWR

A construction permit was issued by the Atomic Energy Commission to Consolidated Edison for Indian Point I in May of 1956. This reactor began commercial operation in 1962.

Indian Point I is also a four-loop PWR. Its original core was composed of 120 box-type fuel elements, each of which was 6 inches square, 8 feet long and contained stainless steel-clad thorium dioxide fuel rods. It produces approximately 585 MW_t, employs 21 cruciform rods for control and is contained in a 9-foot, 9-inch diameter stainless-clad, carbon steel reactor vessel. Each coolant loop contains two reactor coolant pumps, and one steam generator. The reactor operates at a nominal pressure of approximately 1550 psia and an average temperature of 495°F and produces sufficient steam at approximately 420 psia such that after it is superheated to 1000°F by oil-fired superheaters approximately 275 MWe are generated.

3.1.3 Connecticut-Yankee - A Subsequent Large PWR

Construction of this plant began in May of 1964 and commercial operation was achieved in 1967.

Connecticut-Yankee, also a four-loop PWR, has a multiregion core composed of 157 fuel assemblies of 204 stainless steel-clad uranium dioxide fuel rods each. The core is arranged in three concentric fuel regions. At the end of each fuel cycle of approximately one year's length, one-third of the fuel assemblies is removed, the remaining two-thirds is rearranged and a fresh one-third is inserted. The fuel cycle management program permits the achievement of high average fuel burnups of approximately 25,000 MWD/MTU.

The reactor produces approximately 570 MWe and employs 45 cluster rod assemblies for control. The design of these assemblies is significantly different from that of the bladed cruciform rods used in previous reactors. It consists of twenty neutron absorber rods joined together at the top by a spider-like bracket. The absorber rods travel in guide tubes located within the fuel assemblies. This cluster control rod significantly decreased the neutron power peaking that was experienced with the use of cruciform control rods. To further improve the reactor fuel cycle and decrease neutron power peaking, chemical shim control is also employed in the Connecticut-Yankee reactor. This shim control consists of adding a small quantity of boric acid to the reactor coolant. The boric acid serves two functions: (1) It increases the subcritical margin of the core on shutdown, and (2) it gradually and precisely compensates for the thermal activity changes due to fuel depletion and fission product accumulation as it is slowly removed over the course of one fuel cycle.

The highly successful operation of the Connecticut-Yankee PWR and also the similar San Onofre plant have been significant factors in establishing the confidence that utilities now have with regard to nuclear power plants being able to produce electrical power safely and efficiently.

3.1.4 Robert Emmett Ginna - A Large PWR Which Recently Began Operation

Ginna achieved commercial operation in early 1970. It is a two-loop PWR with a core power rating of 1455 MW_t and is capable of a gross output of approximately 496 MWe. Its 12-foot long core is made up of 121 fuel assemblies, each having 179 Zircaloy-4-clad fuel rods arranged in 14 x 14 arrays and containing uranium dioxide pellets. Sixteen of the rod positions in each fuel assembly are occupied by control rod guide tubes and one position is occupied by an instrument tube.

The initial core loading was divided into three roughly concentric regions. New fuel will be loaded into the center region at each yearly refueling.

Reactor control is provided by a combination of cluster rod assemblies and chemical shim. Of the 33 control rods, 29 are full-length and

4 are part-length. The full-length rods have a total reactivity worth sufficient to shut the reactor down from any operating condition even with the highest worth rod stuck in its fully withdrawn position. The four part-length control rods are provided to flatten axial neutron flux variations and to dampen out any spatial xenon oscillations that may result from power changes.

The plant is designed to accept a step-load change of 10 percent and ramp-load changes of 5 percent per minute between 15 percent and 100 percent of full power. The plant is designed for automatic load following, and partial load rejection without, trip.

In-core instrumentation in the form of remotely positioned ion chambers provides neutron flux distribution information to the plant operator.

3.1.5 Oconee 1 - A Modern Large PWR Not Yet in Commercial Operation

Duke Power Company's Oconee Units 1, 2 and 3 received construction permits in 1967. In September 1970, Oconee 1 received favorable ACRS review to commence operation and is scheduled to produce commercial power by mid-1971.

Midland Units 1 and 2 are the ninth and tenth reactors of a series of Babcock & Wilcox Company (B&W) reactors of essentially identical design.* Oconee Unit 1 is the first of this series. It is a two-loop PWR with an ultimate core power rating of 2568 MWe and a net electrical output of 886 MWe. Each loop contains a straight tube once-through steam generator and two reactor coolant pumps. A pressurizer

*The 8 prior units are listed on Lines ~~10-14~~ 6-10 on Page 11-3.

connected to one of the two loops maintains the reactor coolant in a subcooled state. Each of the two reactor coolant outlet pipes contains a calibrated flow tube which is used to measure the reactor coolant flow rate during operation. The reactor will operate at a nominal pressure of 2200 psia with an average coolant temperature of 580°F. The reactor has a 12-foot long core made up of 177 fuel assemblies, each of which contains Zircaloy-4-clad fuel rods. The fuel rods contain uranium dioxide pellets and are arranged in 15 x 15 arrays. Sixteen of the rod positions in each fuel assembly are occupied by control rod guide tubes and one position (the center one) can accept an instrument tube.

The reactor vessel consists of an 171-inch ID cylindrical shell approximately 8-1/2 inches thick.

Reactor control is provided by a combination of cluster rod assemblies and chemical shim. Of the 69 control rods, 61 are full-length and 8 are part-length. In-core instrumentation consists of an assembly of self-powered neutron detectors and a thermocouple.

3.1.6 Midland Units 1 and 2

An application for construction permits for Midland Units 1 and 2 was filed with the AEC in January 1969. Unit 1 is expected to produce commercial power and process steam in 1974.

The reactors for these units are essentially identical to those of the eight B&W units scheduled to precede them into operation. The Midland units are described in Section 7 of this document.

The basic design of the fuel assemblies, control rod assemblies, control rod drives, steam generators, and instrumentation has been confirmed by proof-testing performed by B&W and the actual components will be proven in operation on earlier B&W designed plants.

3.2 Evolution of Engineered Safeguards

Engineered safeguards systems are defined as that equipment, of either static or dynamic design, which is utilized in the event of a reactor accident to limit the environmental consequences of that accident.

The history of engineered safeguards features for commercial pressurized water power reactors began when the Shippingport project was authorized in July 1953. Seventeen years of design experience have been accumulated in safeguards design and the current engineered safeguards equipment installed on present-day plants is the result of design evolution and extensive research and development. During the course of these years, the improvements and capabilities of engineered safeguards features have maintained or increased the protection provided the public against the potential releases of fission products resulting from postulated reactor accidents.

Today there are about 60 commercial pressurized water power reactors that have been designed, constructed or are in operation. All of these plants have engineered safeguards systems to provide protection to the public against radiation hazards.

Shippingport Engineered Safeguards Features

The Shippingport plant[1], which was designed for 335 MW_t, contained some of the engineered safeguards features presently utilized in current designs. A brief summary discussion of these is as follows:

1. The reactor system was housed in a steel container designed to withstand the energy release from a loss-of-coolant accident. The resultant design pressure was 52.8 psia. This building was leak tested and showed that the leakage rates of a fraction of 1 percent per day were achievable.

2. The reactor plant had a safety injection system to supply emergency core coolant in the event of a loss of integrity of the reactor coolant system.

This system contained two 1500 gpm pumps that were automatically actuated when the reactor coolant system pressure decreased to 500 psia and was designed to reflood the core, thereby preventing significant melting or release of fission products.

Engineered Safeguards at Later Plants

With the advent of higher performance reactors, the single safety injection system concept of the Shippingport plant was supplanted by a combination of high-pressure injection systems and low-pressure injection systems to provide emergency coolant to the core in the event of the loss of reactor coolant system integrity. These systems provided a wider range of coolant replacement capability in both flow and pressure to insure adequate core cooling for a complete range of rupture sizes. Typical of such designs was the Yankee plant(2) which had a 770 psia high-pressure injection system and a 300 psi low-pressure injection system, utilizing boric acid for criticality control.

The inability of the natural heat sinks within the reactor building to absorb sufficient quantities of heat to prevent overpressurization of the reactor building structure required the use of supplemental cooling as plant size increased. Both emergency building cooling equipment and spray systems were utilized to prevent overpressurization during the course of the postulated accident. Typical plants which have utilized these concepts during this evolutionary period are Connecticut-Yankee plant and the Ginna plant.

To meet the AEC's siting criteria (10 CFR 100) as plants became larger, either greater exclusion distance or engineered safeguards systems capability must be extended to include reduction of iodine concentration within the post-accident reactor building atmosphere to within acceptable limits defined by the site characteristics.

Two basic types of iodine and particulate fission product removal systems have been incorporated in past designs. One of these is a filter system which removes particulates and absorbs iodine on charcoal as the reactor building air is recirculated through the filtering system. The second employs the reactor building spray droplets to impact particulate matter and wash the iodine from the steam-air atmosphere. The washing is accomplished by a chemical reaction between the iodine and the chemicals contained in the spray droplets.

A typical plant design which included filters for removal of particulate material and iodine absorption was Connecticut-Yankee, which was licensed for construction in 1964.

Spray removal systems using a sodium thiosulfate reagent for iodine removal were first incorporated on Metropolitan Edison's Three Mile Island Plant[3].

The most recent engineered safeguards feature incorporated to provide core protection during the postulated loss-of-coolant accident is the static core flooding system. Thus, the dynamic injection systems were supplemented with fast-acting core flooding systems. These systems contain emergency coolant in pressurized tanks directly connected to the reactor coolant system. These tanks of coolant are separated from the reactor coolant system by check valves that open when the reactor coolant pressure decreases below the pressure in the tanks. The net effect is a rapid insurge of coolant to the core that is proportional to the system demand for coolant replacement. Thus, a large leak would cause rapid reactor coolant system depressurization and maximum flow from the flooding system. Smaller ruptures have lower rates of depressurization and lower flow rates from the core flooding tanks. These static devices respond rapidly to the needs of the reactor for coolant makeup and do not require an external source of power.

This type of engineered safeguards feature was first incorporated on the Consolidated Edison Indian Point II[4] and Duke Power Company Oconee plants[5] and has also been incorporated in applicant's Palisades Plant.

Engineered Safeguards Features of Midland Plant

The Consumers Power Company's Midland Plant Units 1 and 2 incorporate engineered safeguards features that have been the result of plant design improvements over the past several years. Those features which are incorporated to satisfy the siting requirements for the Midland plant are described in detail in applicant's Preliminary Safety Analysis Report.

The reactor is housed in a low leakage (0.1 percent by volume per day) steel-lined prestressed concrete reactor building. Automatic isolation of lines entering the reactor building is effected in the event of an accident requiring isolation. The reactor core is protected against fuel melting during loss-of-coolant type accidents by emergency core cooling systems. These systems are the core flooding system, the high-pressure injection system, and the low-pressure injection system. Radioactive iodine released into reactor building during a postulated loss-of-coolant accident is removed by a building spray system that utilizes a sodium thiosulfate solution to rapidly and irreversibly react with the iodine before it can leak to the environment.

Supplemental reactor building cooling is provided by two independent systems, a reactor building cooling system and the reactor building spray system. These prevent post-accident building overpressurization and provide for rapid depressurization of the building, thus reducing the leakage rate to the environment.

Summary

The evolution of the reactor designs to larger sizes since Shippingport has prompted the development of improved engineered safeguards features to provide environmental protection against the consequences of a major fission product release associated with a postulated loss of reactor coolant. These have evolved from the orderly analysis of design needs and the designs are based upon a wealth of experimental data that verifies design requirements and achievable performance.

The engineered safeguards features incorporated on the Midland plant are essentially identical to those used on other reactor plants presently approved for construction. Accordingly, the engineered safeguards features used for this plant represent fully engineered designs that have been thoroughly evaluated and found to provide protection of the public well within AEC guideline values.

3.3 Reactor Buildings

The Midland reactor buildings are posttensioned reinforced concrete structures. In the design of these buildings, full advantage is being taken of the experience gained in the review of similar designs with the AEC for the Florida Power and Light Company's Turkey Point Plant, Wisconsin-Michigan Power Company's Point Beach Plant, Duke Power Company's Oconee Nuclear Station, Arkansas Power and Light Company's Russellville Plant, the Sacramento Municipal Utilities District Rancho Seco Plant and the Palisades Plant, as well as reactor building designs by others which meet the same functional requirements. All the foregoing plants which have similar posttensioned reactor buildings have received construction permits. Further, the Palisades and Point Beach reactor buildings have been successfully leak tested and pressure tested at 115 percent of their design pressure levels. The reactor building is designed to contain in excess of the maximum pressure resulting from the most severe postulated loss-of-coolant accident. The reactor building integrity is assured by means of a 1/4-inch steel liner plate which completely encloses the interior of the reactor building. The liner plate is provided with a leak chase system which consists of steel channels welded over the liner plate seams. These channels are continuously pressurized to assure that any leaks which may occur would be inward. All liner plate penetrations are provided with a pressurized boundary at a pressure greater than the building design pressure.

Table 3.3-1[6] compares the principal differences of the Midland reactor building with reactor buildings of other plants which received construction permits. It should be pointed out that the 170-wire tendon to be used for the Midland reactor building was developed for the prestressed concrete reactor vessel for the Fort Saint Vrain plant and stressing equipment has provided 1000 cycles of load applications, more than sufficient to stress all tendons on this reactor building, in one test series alone.

Table 3.3-1

Comparisons With Other Reactor Buildings

		Consumers Power Co Midland Plant	Consumers Power Co Palisades Plant	Arkansas Power & Light Co Russellville Plant
1	Diameter	116'-0"	116'-0"	116'-0"
2	Design Pressure	67 Psig	55 Psig	59 Psig
3	Wall Thickness	3'-6"	3'-6"	3'-9"
4	Dome Thickness	3'-0"	3'-0"	3'-3"
5	Level of Prestress	1.2P-1.5P(1)	1.5P	1.5P
6	Wires per Tendon	170 (Maximum)	90	186
7	Size of Wire	1/4"	1/4"	1/4"
8	Buttresses	3	6	3

		Sacramento Municipal Utility District Rancho Seco	Florida Power & Light Co Turkey Point	Wisconsin Michigan Power Co Point Beach
9	Diameter	130'-0"	116'-0"	105'-0"
10	Design Pressure	59 Psig	59 Psig	60 Psig
11	Wall Thickness	3'-9"	3'-9"	3'-6"
12	Dome Thickness	3'-0"	3'-3"	3'-0"
13	Level of Prestress	1.2P-1.5P(1)	1.5P	1.5P
14	Wires per Tendon	55 Strands	90	90
15	Size of Wire	1/2" (7 Wire)	1/4"	1/4"
16	Buttresses	3	6	6

References

1. The Shippingport Pressurized Water Reactor - 1958 - Addison-Wesley Publishing Co, Inc.

2. Part B License Application AEC Docket No. 50-29 "Technical Information and Final Hazards Summary Report."

3. Metropolitan Edison FSAR (Docket No. 50-289)

4. Indian Point No. 2 (Docket No. 50-247)

5. Oconee No. 1 (Docket No. 50-269)

6. PSAR, Section 5.1.

4.0 ENVIRONMENTAL QUALITY

4.1 Introduction

In designing the Midland Plant, applicant is making every effort to consider its impact on the environment, having as a goal the preservation and enhancement of environmental quality.

To help assure that this objective is met, air and water monitoring programs are being established for the plant. These programs are described in Section 10 of this summary.

4.2 Air Quality

Trace amounts of gaseous fission products, less than a few percent of the AEC limits, will be released to the environment. The radioactive waste gases will be held up in the waste gas decay tanks and filtered to limit the off-site release to as low a level as practicable.

4.3 Water Quality

To reduce the heat load on the Tittabawassee River and comply with Michigan water quality standards, an 880-acre cooling pond will be constructed adjacent to the plant. The pond is designed to accept 100% of the waste heat from the plant. It will be necessary to flush solids from the pond to the river. However, this process merely returns to the river solids present in the water drawn into the pond from the river which have concentrated in the pond; and there will be no net addition of solids to the river from the Midland Plant due to this process.

Due to evaporation of water from the pond, some water vapor will be released to the atmosphere. Experience at similar facilities indicates that fogging will occur only over the immediate vicinity of the pond. There will be less release of water vapor from the pond than if cooling towers were used to accept the entire waste heat load.

There will be a controlled release of radioactive nuclides to the river from the plant's liquid radioactive waste system. This system processes radioactive liquid waste through tanks, filters, demineralizers and evaporators to reduce radioactivity to levels as low as practicable within AEC limits prior to discharge. This release will be less than a few percent of the AEC limits.

4.4 Solid Wastes

Radioactive solid wastes, such as demineralizer resins, spent filter elements, clothing, rags, and other solid wastes will be packaged in suitable containers and shipped offsite for disposal by an AEC-licensed contractor. Spent fuel will similarly be shipped offsite to a fuel reprocessing facility.

4.5 Land Use and Aesthetics

The Midland Plant's functional design will be blended harmoniously with the surroundings. The plant, which will occupy an 1190.38-acre site along the south shore of the Tittabawassee River, is located directly across the river from The Dow Chemical Company's industrial complex. The plant structures will be located directly adjacent to the river. Dow waste ponds are located nearby. The 880-acre cooling and storage pond will occupy an area generally to the south of the plant structures, as shown on Appendix B, Fig 4. Applicant will plant trees and shrubs along the pond dike to screen it from a residential subdivision near the western boundary and from a road along the south boundary. The center of the pond dike will be set back from the site boundary a distance of not less than 160 feet and a security fence will surround the dike.

Because there will be no bulk fuel storage and handling facilities or high stacks, the plant will be streamlined in appearance in comparison to fossil-fired power plants, see Appendix B, Fig 1. Noise from the plant during normal operation will be minimal and not detectable at the site boundary.

4.6 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires, among other things, that all agencies of the Federal government include in every recommendation or report on major Federal action significantly affecting the quality of the human environment, a detailed statement by the responsible official on the following:

"(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."

Prior to making such a detailed statement, the agency is required to consult with and obtain comments of any Federal agency which has jurisdiction by law or special expertise with respect to environmental impact.

In compliance with the policy of the Atomic Energy Commission, applicant has prepared and filed with the Commission an environmental report providing information on the above five points. The Atomic Energy Commission has circulated it for comments to Federal agencies having jurisdiction or special expertise with respect to environmental impact and, by publication of notice in the Federal Register, 35 FR 12795, August 12, 1970, has made the report available to local agencies. Comments have been received from the Federal Power Commission, the Department of Agriculture, the Department of Housing and Urban Development, the Department of Defense and Michigan Department of Natural Resources.

5.0 OTHER GOVERNMENTAL AGENCIES

Consumers Power Company intends to acquire all necessary regulatory approvals for construction and operation of the Midland Plant. It has sought to fully cooperate with all governmental agencies having an interest in the plant and has attempted to keep all agencies fully informed. As part of this policy of cooperation, Consumers Power has served copies of the application with all amendments as they were filed on the Mayor of the City of Midland, on the Supervisor of Midland Township, and on the Chairman of the Board of Commissioners of Midland County and has served six copies on the State of Michigan to be distributed to interested agencies.

Besides applying to the Atomic Energy Commission for a permit to construct and a license to operate the Midland Plant, Consumers Power on June 9, 1970 filed with the Michigan Water Resources Commission a Statement of New or Increased Use of Waters of the State for Waste Disposal Purposes and on August 28, 1970 applied to the Michigan Air Pollution Control Commission for authority to construct and operate air pollution control equipment at the Midland Plant. Following a public hearing held on August 10, 1970, the Water Resources Commission issued an Order of Determination, dated October 15, 1970, imposing specific limits on the proposed use of the water of the Tittabawassee River by Consumers Power. The Michigan Air Pollution Control Commission is considering Consumers Power's application and is expected to act in the near future.

Consumers Power received, following a public hearing, approval for its proposed use of land in the pond area from the Midland Township Zoning Board of Appeals and received a building permit from the Midland Township Building Inspector. Consumers Power has provided information in relation to construction of the plant to the City Commission of Midland, the Midland Township Board, the Midland County Board of Commissioners, the Midland County Drain Commissioner, the Midland County Road Commission, the Michigan Departments of Public Health, Labor and Natural Resources, the Michigan Public Service Commission, the Michigan Water Resources Commission, the Governor's Study Committee on Atomic Energy, the US Coast Guard and the US Army Corps of Engineers.

Consumers Power has received miscellaneous approvals relating to the plant from several of these agencies and will work closely with these and any other agencies having an interest in the plant in order to secure all necessary approvals and to assure that these governmental agencies are fully informed as to the status of the project.

The Midland Township Board by resolution on September 9, 1970 let it be known that it encouraged the installation of the Midland Plant at the plant site located in Midland Township. The Midland County Board of Commissioners by resolution on August 11, 1970 supported the location and development of the Midland Plant in Midland County. On August 26, 1970, the Midland County Road Commission by resolution supported the location and development of the Midland Plant in Midland County.

6.0 SITE CHARACTERISTICS

6.1 Location

The Midland Plant is to be constructed on the south shore of the Tittabawassee River adjacent to the southern limits of the City of Midland, Midland County, Michigan. The site and immediate vicinity are shown in Appendix B, Figures 3, 4 and 5[1].

All land comprising the site will be controlled by applicant[2]. This includes all land bounded by the Tittabawassee River bank on the north and east, on the south by Gordonville Road and on the west by farmland and scattered residences.

6.2 Population[3]

The plant exclusion area has a minimum radius of 0.31 mile. The exclusion distance to the south site boundary, encompassing the pond, is 1.12 miles.

The distance to the boundary of the low population zone is 1 mile, within which there is estimated to be 38 permanent residents plus portions of The Dow Chemical Company industrial complex.

The population distribution is shown in Appendix B, Figure 6. The siting and safeguards provisions of the plant are in accordance with the AEC guidelines set forth in 10 CFR Part 20 ("Standards for Protection Against Radiation") and 10 CFR Part 100 ("Reactor Site Criteria").

6.3 Land Use

Generalized descriptions of the land use within five miles of the site are given below[4]. Present use of land was determined by examining geological survey m[illegible] and aerials of the area. Future use was based on past development, industrial trends and suitability of land for various purposes

North	- (0-1.5 miles)	- Heavily industrialized. Dow's main industrial complex lies in this area. Room for industrial development in NNE section.
	- (1.5-4 miles)	- Contains the populated residential, commercial community of Midland. Area is nearly saturated with buildings. Little growth expected.
	- (4-5 miles)	- Primarily residential. This area is expected to develop into a residential suburban community.
East	- (0-1 mile)	- Heavily industrial, area saturated.
	- (1-5 miles)	- Sparsely populated residential area. Many forested acres, scattered farming. Expect industrial growth 1-2 mile section. This is another area for suburban development.
South	- (0-1 mile)	- Land contained within site.
	- (1-3 miles)	- Mostly forested lands, some farming. Potential area for industrial expansion.
	- (3-5 miles)	- Primarily farming, scattered nonfarming residents, very few commercial establishments.
West	- (0-1 mile)	- Industrial property owned by applicant and Dow.
	- (1-2 miles)	- Mostly suburban residential, light farming. Room for suburban residential development.

- (2-5 miles) - Primarily agricultural, sparsely populated. Some forested land.

The area 5-50 miles from the site is primarily used for farming, where not forested, except for the industrial communities of Bay City, Flint, and Saginaw. A large portion of the area northeast of the site is public land used for hunting and camping.

6.4 Meteorology

The site meteorology has been extensively investigated to provide an assessment of environmental consequences of routine and accidental releases of radioactivity. The topography at the site is comparatively flat with elevations ranging from 600 to 634 feet above mean sea level. It is estimated that there are no significant changes in the topography greater than 50 feet within 50 miles. Thus, topographically induced or altered winds should not be important at this site.

Temperatures of 90 degrees or higher occur on an average 14 times per summer and of zero or lower on an average of 6 times during the winter. Mean annual precipitation at Midland is 29.8 inches. Rainfall is greatest in June, averaging 3.15 inches. Snowfall totals 33.3 inches during an average winter. Cloudiness is greatest in the late fall and winter. Prevailing wind direction is southwest and average hourly velocity is greatest in the early spring and lowest in late summer and early fall. A study was made of the site atmospheric diffusion characteristics, utilizing conservative meteorological conditions[5]. Extensive meteorological data was available from the Tri-City Airport and Dow. A meteorological program for the site will commence at least two years before fuel loading.

6.5 Surface Water Hydrology

Surface water investigations were made in connection with the safety aspects of the plant. These included the magnitude of possible floods and possible failure of upstream dams(6).

The maximum recorded flood since 1907 reached a stage of 610.0 feet in 1916(6).

The probable maximum flood discharge at the plant site has been conservatively calculated to be about 270,000 cfs which includes the effect of upstream dam failures. This discharge is calculated to result in a probable maximum flood level of 632 feet at the plant site which level has been used as a basis for plant design.

The plant area will be filled to elevation 634 and thus the vital installations are protected against water damage in the unlikely event of a probable maximum flood.

6.6 Groundwater Hydrology(7)

The presence of a thick, impermeable clay member has produced two hydrologic conditions at the site. They are:

1. A perched water table in the sand above the clay.
2. An artesian aquifer in the sand and gravel underlying the clay.

The perched water table is in the upper sand which generally is less than 50 feet deep in the borings. The quantity of water in these surface sands is limited and is not a source of domestic supply in the site area. Small domestic supplies are obtained from the underlying confined aquifer.

The thick, impermeable clay layer, which acts as the confining media preventing the upward flow of the artesian water, also prevents the downward percolation of surface water from the plant area.

Water wells located within the cooling pond area have been sealed to insure that cooling pond water does not seep into the domestic supply and that no artesian groundwater leaks into the cooling pond water.

6.7 Site Geology[8]

6.7.1 General

Site investigations were conducted to evaluate the geologic conditions that are pertinent to the design, construction and operation of the Midland Plant. These investigations indicate that the Midland area is underlain by two types of glacial deposits. These are a loose glacial lake deposit overlying a dense glacial till. The plant is founded on the dense till. These deposits overlie bedrock which is the Pennsylvanian Saginaw formation composed of nearly flat-lying shales, sandstones, and siltstones. The glacial deposits vary in thickness from 350 to 360 feet.

6.7.2 Salt Solution Cavities

Underlying the site are thin salt beds encountered in the Devonian formation of the Detroit River section at a depth between 4100 and 4300 feet. The Dow Chemical Company has mined these salt beds for some time and has also extracted brine from the Devonian Sylvania sandstone at a depth of 5100 feet. Overlying the area mined are dense beds of limestone, dolomite, shale and sandstone.

The maximum surface subsidence has been investigated by two separate consulting firms, Woodward-Clyde & Associates and General Analytics, Inc. One firm is experienced in foundation investigations, and the other is experienced in mine settlement investigations. Experts with these firms reviewed the information from the Dow brine well mining operations. The data include drilling records and drill corings of the rock strata overlying the salt solution cavities, accurate records of materials removed and records of ground surface elevations.

An independent calculation of surface subsidence was made by each consultant. In one case, the consultant used an analytical approach based on estimated cavity openings and the known elastic properties of the surrounding rock strata. The other consultant used an empirical method developed to predict surface subsidence of mines in England. The conclusion reached by both consultants was that for the salt wells in the area of the plant site, the maximum surface subsidence which could be expected would be less than 1 inch[9].

Furthermore, if subsidence were to occur, it would affect a large area due to the spacing of the wells, their great depth and the competency of the overlying flat-lying sedimentary rocks. Such a broad regional subsidence would have no significant effect on surface structures, which cover a small area compared to the probable subsided area. The negligible predicted maximum subsidence has been confirmed by the recorded surface elevations over the past 10 years. The Dow Chemical Company has observed no measurable surface subsidence due to the salt solution extraction. To further insure the safety of the Midland Plant, Dow will not drill any new brine or salt wells within one-half mile of the plant site.

6.8 <u>Seismology</u>(10)

The Midland site is located in a region of slight seismic activity. Although earthquakes have been felt in this region of the United States, Midland experienced all with low intensity. The maximum intensity experienced at the proposed Midland nuclear site as a result of any historic earthquake is V on the Modified Mercalli scale.

Intensity V corresponds to a surface acceleration of 0.03 g on Hersberger's (1956) curve. For design of the plant Class I structures,* a conservative value of 0.06 g will be used for the operating basis earthquake, and 0.12 g acceleration will be used for the design basis earthquake for safe plant shutdown.

No faults are mapped in the surficial deposits of the southern peninsula. The active Keweenaw fault exists approximately 325 miles northwest of the site on the Upper Peninsula. This fault, however, is not related geologically to the structural province of the Michigan Basin and its activity is not important in the evaluation of the Midland site. A less important fault zone about 240 miles northwest of the site in the vicinity of the Menominee Range does not appear to be active.

*Class I structures, systems and equipment are those whose failure could cause uncontrollable release of reactivity or those essential for immediate and long-term operation following a loss-of-coolant accident.

6.9 Foundations

The reactor buildings and lower portions of the auxiliary building are at elevations such that the foundations are established on the stiff-to-hard cohesive soils which underlie the site. These soils are considered to provide excellent foundation support without excessive settlement under both static and dynamic conditions of loading[11]. These Class I structures are founded on earth-supported mat foundations.

The south portion of the auxiliary building has its base at elevation 610 while the existing ground surface soils in this area vary between elevation 605 and elevation 612. The surface soils in this area are loose sands of variable thickness which do not provide suitable foundation support. Consequently, these soils are to be removed down to the underlying very stiff-to-hard cohesive soils and will be replaced with controlled compacted granular or cohesive fill. All other Class I structures or components will also be founded on the stiff, hard cohesive soils or on engineered compacted fill material. Furthermore, in the area of the Turbine Building, all loose sands, soft or compressible clay soils, and organic soils will be excavated and replaced with suitable fill material.

References

1. PSAR, Sections 1.2.1 and 2.2.1
2. PSAR, Section 2.2.2
3. PSAR, Section 2.2.5
4. PSAR, Section 2.2.6
5. PSAR, Appendix 2A
6. PSAR, Appendix 2B
7. PSAR, Section 2.6
8. PSAR, Section 2.5.3
9. The Woodward-Clyde & Associates report is appended to Item 2.17 submitted by Amendment No 7; it follows Amendment No 5 in Volume II of the PSAR. The General Analytics, Inc report was submitted in Amendment No 10, PSAR Volume III.
10. PSAR, Section 2.7
11. PSAR, Section 2.8.4.3

7.0 DESCRIPTION OF MIDLAND PLANT

7.1 Introduction

A description of plant features and layout, as well as an evaluation of plant safety, is set forth in the application and its amendments. The plant description emphasizes the concepts, guidelines and criteria which will govern final design.

The station will consist of two reactor buildings, an auxiliary building (including fuel storage, control room and radwaste area), a turbine structure (housing two turbines), an administration building (including offices, a shop and warehouse), a water storage and cooling pond, a switchyard and various other auxiliary structures and equipment. Arrangement of the Midland Plant is shown in Appendix B, Figure 3. Section 9, together with Appendix A, presents a comparison of the nuclear steam supply system design parameters of the proposed Midland Plant with those of Duke Power Company's Oconee Unit 1; Commonwealth Edison Company's Zion Plant and the Sacramento Municipal Utility Company's Rancho Seco Unit 1 Plant.

The following subsections are a summary of the principal features of the plant which are significant with respect to safety considerations.

7.2 Reactor and Reactor Coolant System

The reactors for the Midland Plant are of the pressurized water type. They have an initial core rating of 2452 MW_t each and together will produce approximately 21×10^6 lb/kW steam for production of electricity and process steam[1]. The nominal operating pressure for the reactor is 2185 psig, with an average core outlet temperature of 604°F[2]. The reactor coolant system is designed for a pressure of 2500 psig at a nominal temperature of 650°F[3]. The nuclear steam systems are essentially identical to eight other B&W units which have previously received construction permits.

The reactor core is approximately 129 inches in diameter, with an active height of 144 inches[4]. It is made up of 177 fuel assemblies, each consisting of a 15 x 15 array of fuel rods held in place by mechanical spacer grids. The array of fuel rods consists of 208 zircaloy tubes containing uranium dioxide, 16 control rod guide tubes, and a center tube available for an in-core instrumentation assembly[5]. There are approximately 207,500 pounds of uranium dioxide in the core[6].

The thermal and hydraulic design limits of the core are conservative, and are consistent with those of other pressurized water reactors currently in operation or under construction[6,7].

Core reactivity is controlled by a combination of 49 movable control rod assemblies, a neutron absorber dissolved in the coolant, and burnable absorber rod assemblies[8]. The control rods are an alloy of silver-indium-cadmium encapsulated in stainless steel. The dissolved neutron absorber is boric acid. The burnable absorber rods are sintered Al_2O_3-B_4C encapsulated in stainless steel[9].

Eight part length axial power shaping rod assemblies are provided to thwart any tendency toward axial power shifts resulting from a redistribution of xenon[8,10].

The control rods are used for short-term reactivity control associated with the changes in power level and also with changes in fuel and burnable absorber burnup between periodic adjustments of dissolved boron concentration[11]. The reactor can be shut down by the movable control rods from any power level at any time. Each movable control rod assembly and axial power shaping rod assembly contains 16 control rods, and is actuated by a separate control rod drive mechanism mounted on the top head of the reactor vessel. Upon trip, all control rod assemblies fall into the core by gravity causing immediate reactor shutdown.

The control rod drive and axial power shaping rod drive mechanisms are sealed drives of the roller nut type in which a lead screw coupled to the control rod assemblies is axially driven by the rotary motion of a pair of roller nut segment arms. The segment arms which are within the pressure housing are part of the drive motor and are electrically driven by the motor stator which is external to the pressure housing. The segment arms are held in engagement with the lead screw whenever the drives are electrically energized. The reactor trip signal or loss of power to the control rod drives causes the roller nut segment arms to disengage from the lead screw causing the rod assemblies to fall into the core. The axial power shaping rod drive mechanism is modified so that the roller nut assembly will not disengage from the lead screw on reactor trip or loss of electrical power(12).

Seventy-two of the fuel assemblies will be utilized as locations for burnable absorber rod assemblies(13). Each assembly has 16 burnable absorber rods, a stainless steel spider, and a coupling mechanism for positive coupling with the fuel assembly hold-down latch(14).

The concentration of dissolved neutron absorber in the reactor coolant may be adjusted to control relatively slow moving reactivity changes and to provide a safe shutdown margin where a cooldown to reactor building ambient temperature is required(15).

The core is contained within a cylindrical reactor vessel having internal dimensions of 14 feet 3 inches in diameter and 37 feet 4 inches in height. The vessel has a spherically dished bottom head with a bolted removable spherically dished top head(16). The reactor vessel is constructed of carbon steel with all interior surfaces clad with austenitic stainless steel. The reactor vessel is manufactured under close quality control, and several types of nondestructive tests are performed during fabrication. These tests include radiography of welds, ultrasonic testing, magnetic particle examination, and dye penetrant testing(17). Specimens of reactor vessel materials will be placed in the reactor adjacent to the inside surface of the reactor vessel. During operation, these specimens will be subject to irradiation similar to the shell of the reactor vessel. A portion of the specimens will be removed periodically and tested to ascertain the effects of radiation on the reactor vessel material[18].

The two coolant loops are connected to the reactor vessel by nozzles located near the top of the vessel. Each loop contains one steam generator, two motor-driven coolant pumps, and the interconnecting piping. The reactor coolant piping is carbon steel clad on the inside surface with austenitic stainless steel[19]. Reactor coolant is pumped from the reactor through each steam generator and back to the reactor inlet by two 88,000 gpm centrifugal pumps located near the outlet of each steam generator[20]. The reactor coolant pumps are vertical, single-stage, shaft-sealed units having bottom suction and horizontal discharge. Each pump has a separate, single-speed, top-mounted motor, which is connected to the pump by a shaft coupling.

The steam generator is a vertical, straight-tube-and-shell heat exchanger which produces superheated steam at constant pressure over the power range. Reactor coolant flows downward through the tubes and steam is generated on the shell side[21].

The pressurizer, a vertical surge tank approximately half-filled with reactor coolant and half-filled with steam, is connected to the reactor coolant system. The operating pressure of the system is maintained by operating electric immersion heaters to increase pressure or by spraying reactor coolant water into the steam within this pressurizer tank to reduce pressure. Self-actuated safety relief valves connected to the pressurizer prevent overpressurization of the reactor coolant system[22].

The reactor vessel, steam generator, and pressurizer will be designed, manufactured and tested in accordance with Section III of the ASME Code. The reactor coolant piping will conform to USASI B31.7 and the reactor coolant pump casings will be manufactured in accordance with Section III of the ASME Code, where applicable[23].

7.3 Reactor Building

The reactor building is designed to completely enclose the reactor coolant system and portions of the auxiliary and engineered safeguards systems. It is a reinforced concrete structure with a post-tensioned system in the shape of a cylinder with an elipsoidal-domed roof and a flat foundation slab. The cylindrical wall and dome are prestressed by a post-tensioning system, consisting of steel tendons. The building will have three vertical and horizontal top and bottom buttresses to which tendons will be anchored. The foundation slab is conventionally reinforced with high-strength reinforcing steel. The inner surfaces of the entire structure are lined with welded steel plate, 1/4-inch minimum thickness, which functions as a leak-tight membrane. The foundation mat will be bearing on the hard, stiff blue clay and will be approximately nine feet thick.

The building is designed to sustain safely all internal and external loading conditions which may be expected to occur during the life of the station or which could result from postulated accidents to the reactor's primary coolant system[24]. The tendon system used in the structure is of the unbonded type with a protective compound used to prevent corrosion.

The reactor building is so designed that, with the engineered safeguards systems provided, any leakage of radioactive materials to the environment will be well within the AEC's guidelines (10 CFR 100) for any of the postulated accidents. The integrated leak rate at design pressure will not exceed one-tenth of one percent by volume, within 24 hours. Furthermore, the reactor building will be designed to resist flotation due to the maximum probable flood.

Prior to operation, the reactor building will be subjected to a structural integrity test and leak rate test. The structural integrity test will be conducted at 115 percent of design pressure. Periodic leak rate tests will be performed to assure integrity of the reactor building. A tendon surveillance program will provide assurance that the tendons are free from harmful corrosion and that excessive steel relaxation has not taken place[25].

Reactor building materials and workmanship will be inspected to ensure compliance with appropriate codes, specifications, and standards. Materials to be inspected and tested include concrete, liner plate, prestressing system materials, hatches, penetrations, structural and reinforcing steel[26].

Provisions have been included for in-service pressure testing of personnel hatches and other penetrations[27].

7.4 Engineered Safety Features

Engineered safety features for each nuclear unit are provided to prevent or mitigate the effects of accidents which result in release of radioactivity.

The engineered safety features fulfill the following functions in the unlikely event of a serious loss-of-coolant accident:

a. Protect the fuel cladding.

b. Maintain reactor building inegrity.

c. Reduce the driving forces for reactor building leakage.

d. Remove fission products from the reactor building atmosphere.

The engineered safety features can be grouped into emergency core cooling systems, reactor building cooling systems, and fission product control systems[28].

The emergency core cooling systems contain both passive flooding systems and pumping systems. The passive flooding system consists of two pressurized core flooding tanks which automatically discharge borated water into the reactor vessel in the event that the reactor system pressure drops below 600 psi. The pumping system consists of two completely independent subsystems. Each subsystem contains both a high-pressure and a low-pressure injection pump. Either subsystem, in conjunction with the core flooding tanks, is capable of protecting core integrity for any size leak up to and including a double-ended rupture of the largest reactor coolant pipe. Either subsystem can supply coolant directly from the borated water storage tank or by recirculation from the reactor building sump through heat exchangers which cool it before it is returned to cool the core[29].

The reactor building cooling system, which is made up of two separate and independent heat removal systems, limits the pressure in the reactor building following a loss-of-coolant accident. One system contains four separate air cooling units. The other system contains redundant spray headers which spray low temperature borated water into the reactor building to cool it. The spray water also contains chemical additives as described below. Each of these systems without the other has the heat removal capability to maintain the reactor building pressure below its design pressure level[30].

The primary control of released fission products following a postulated loss-of-coolant accident is provided by the reactor building. A second means for controlling released fission products is the iodine removal spray system which consists of redundant subsystems which utilize chemicals mixed in the reactor building spray water to absorb the iodine released from the reactor coolant system and render it unavailable for leakage from the reactor building. For the postulated maximum hypothetical accident the reactor building and either one of the two redundant reactor building spray systems will limit radiation exposures at the exclusion boundary and low population zone boundary to values within AEC safety guidelines (10 CFR 100)[31].

7.5 <u>Instrumentation and Control</u>

Redundant networks of instrumentation and controls will be provided to ensure the safe operation of the Midland Plant. The reactor protection system and the engineered safeguards actuation system are designed to meet the requirements of the proposed "Standard for Nuclear Power Plant Protection Systems," IEEE-279, Rev 10. The engineered safety features actuation system monitors plant conditions and automatically initiates operation of the engineered safety features systems, if required[32]. This system initiates emergency core cooling systems on signal of high reactor building pressure or low reactor coolant system pressure. The reactor protection system monitors parameters related to safe operation and shuts down the reactor if an operating limit is reached[33]. The operating limits are well below the safety limits. Shutdown will be accomplished by interrupting power to the control rod drive mechanisms and allowing the control rods to drop into the reactor core. Alarms[34] are provided to alert the operator to abnormal operating conditions, and interlocks[35] are provided to prevent operations which could lead to potentially hazardous conditions.

The nuclear instrumentation system monitors reactor power from start-up level through 125 percent of full power operation. There are separate overlapping instrumentation channels for the source range, the intermediate range, and the power range[36].

Following proven power station design philosophy, all control stations, switches, controllers, and indicators necessary to start up, operate, and shut down the nuclear unit will be placed in the centrally located control room. There will be sufficient information display and alarm monitoring to ensure safe and reliable operation under normal and accident conditions. Special emphasis will be given to maintinaing control room integrity during accident conditions[37].

For the unlikely contingency that occupancy of the control room may be temporarily denied, the capability will be available for taking the plant to, and maintaining the plant in a safe shutdown condition from other locations in the plant[38].

The instrumentation signals sent to control and safety circuits from common transmitters are made fully independent by the use of isolation amplifiers. The effectiveness of these isolation amplifiers has been demonstrated by analysis and by actual test of prototype equipment.

A radiation monitoring system monitors radiation levels in selected plant areas and in plant effluent released to the environment, provides an early warning of possible equipment malfunction or potential radiological hazard. The radiation monitoring system includes continuous automatic monitoring and is supplemented by periodic sampling[39].

7.6 Electrical Systems[40]

The Midland Plant will generate electric power at 22 kV and 24 kV, respectively. This power will be fed through separate isolated phase buses to the unit main transformers where it will be stepped up to 345 kV transmission voltage and delivered to the switchyard on separate overhead lines. The units and associated switchyard are part of the Consumers Power Company integrated electric system, which is described in Section 2.1 of this summary.

The design of the electrical systems for the Midland Plant units is based on providing the required electrical equipment and power sources to ensure safe, reliable operation and safe, orderly shutdown of the unit under any normal or emergency conditions. The following sources of power are available to provide redundancy and to assure a supply of electrical energy to the station safety systems under all credible circumstances:

1. The five 345 kV transmission lines which terminate at the Midland Plant switchyard provide start-up and standby power through the 345-138 kV step-down substation, 138 kV Start-Up Line and Start-Up Transformer No 1.
2. Start-Up Transformer No 2 provides an alternate off-site power source via a separate 138 kV line from a Consumers Power Company substation serving Dow.
3. Each unit will continue to supply power to its own auxiliary systems in the unlikely event of a trip separation from the transmission system.
4. Upon loss of all sources of power described in 1, 2 and 3 above, power will be supplied from the two automatic, fast start-up diesel engine generators. These are sized so that either can carry the engineered safeguards load for one plant plus the safe shutdown load for the other unit.
5. The station battery is sized to provide a safe and orderly shutdown of each unit in the event that all a-c power is lost.

These normal, standby and emergency sources of auxiliary electrical power supply redundant plant auxiliary, engineered safeguards and reactor protection systems through separate and independent distribution systems.

7.7 Auxiliary Systems

Auxiliary systems are provided to supply reactor coolant makeup and pump seal water, to cool the reactor during shutdown, to cool components, to ventilate station spaces, to handle fuel, to cool spent fuel, and to adjust the concentration of various chemicals in the reactor coolant[41].

Reactor coolant makeup and seal water is supplied by the makeup and purification system. This system, which also serves the engineered safeguards function of providing high-pressure emergency core coolant, maintains the proper coolant inventory in the primary system, maintains the seal water flow, adjusts the concentration of dissolved neutron absorber in the reactor coolant and maintains proper water chemistry[42].

The decay heat removal system cools the reactor when the reactor system is depressurized for maintenance or refueling. This same system serves the engineered safeguards functions of providing low-pressure emergency core coolant and of recirculating borated water to cool the core in the unlikely event of a loss-of-coolant accident[43].

The chemical addition system adds boric acid to the reactor coolant system for reactivity control, potassium hydroxide for pH control, and hydrogen and hydrazine for oxygen control[44].

The cooling water systems maintain temperatures throughout the equipment and structures of the station[45]. Appropriate normal and emergency ventilation systems are provided in the plant[46].

A fuel handling system[47] provides the means for safe, reliable handling of fuel until it is shipped from the station as used fuel. Irradiated fuel is handled under water at all times until after it is placed into a shipping cask. The water provides a radiation shield as well as a reliable source of cooling for the irradiated fuel assemblies. A fuel pool cooling system maintains the temperature and purity of the spent fuel storage pool water within acceptable limits[48].

7.8 Steam and Power Conversion System[49]

The steam and power conversion system is designed to accept steam from the nuclear steam system. One portion of this heat energy is converted to electrical energy by the turbine generators. A second portion of the heat energy is used in the process steam reboilers to generate process steam for Dow. The circulating water system, utilizing cooling pond water, will dissipate the balance of the heat energy which is rejected by the turbine condensers.

7.9 Process Steam System

Steam from the steam and power conversion systems is used in indirect tertiary heat exchangers (reboilers) to generate process (tertiary) steam for Dow. The function of the reboilers is to provide complete physical separation between the turbine plant cycle and the process steam delivered to Dow[50].

7.10 Cooling Pond

Turbine condenser cooling water is stored in a cooling pond. The pond is sized to allow for all water losses from the pond, without make-up from the Tittabawassee River, during the three-month period when the river flow is low[51]. The emergency service water pond is a depressed area in the cooling pond, which will provide water storage for reactor decay heat removal in the unlikely event of a dike failure[52].

7.11 Radioactive Waste System

Radioactive gaseous, liquid and solid wastes in the station are handled by the waste disposal systems. These systems contain the equipment necessary to safely collect, process and prepare for disposal or reuse of the radioactive wastes which result from reactor operation. These systems are designed to minimize the release of radioactive material from the plant to the environment and will maintain releases well below the limits of 10 CFR 20[53].

The gaseous and liquid radwaste releases from the plant are anticipated to be as low or lower than other plants in operation or under construction, except that the liquid radwaste release will not be as low as that of the Rancho Seco Plant which is not situated near a waterway and cannot discharge liquid wastes. The maximum expected radwaste release rates from the plant are as follows:

Gaseous	88,600 Curies/Year (30-Day Holdup)
Tritium	6,300 Curies/Year
Other Liquid Wastes	0.1 Curies/Year

The above release rates are based upon 1 percent failed fuel, up to 1 gpm leakage into the turbine cycle and 30 percent tritium release from the fuel[54]. The quantities for failed fuel and steam generator leakage are based upon current operating experience representing maximum levels that might be expected. The quantity level shown for tritium release is a conservatively high assumed value pending further operating experience with the current generation of chemical shim, zircaloy fuel-clad PWR. Some estimates have been as low as 1 percent with a corresponding decrease in the tritium waste discharge rate.

7.12 Shielding

Shielding throughout the plant, primarily in the form of heavy concrete walls, insures that radiation exposures to the general public and to operating personnel are within the limits prescribed by the AEC (10 CFR 20)[55].

References

1. PSAR, Table 4-5
2. PSAR, Table 3-1
3 PSAR, Section 4.3.1
4. PSAR, Table 3-2
5. PSAR, Table 3-1
6. PSAR, Table 1-2
7. PSAR, Section 3.2.3
8. PSAR, Section 3.2.2; Table 3-2
9. PSAR, Section 3.2.4.3.7; Table 3-22
10. PSAR, Section 3.2.4.3.6; Figure 3-59
11. PSAR, Sections 3.2.2.1.2, 3.2.4.3.5; Figure 3-58
12. PSAR, Section 3.2.4.3.2
13. PSAR, Table 3-22; Figure 3-4
14. PSAR, Section 3.2.4.3.7
15. PSAR, Sections 3.2.2.1.2, 3.2.2.1.3
16. PSAR, Section 4.2.2.1 and Table 4-3

17. PSAR, Sections 4.5.1 and 4.5.2

18. PSAR, Section 4.4.3

19. PSAR, Table 4-12

20. PSAR, Section 4.2.2.4 and Table 4-7

21. PSAR, Section 4.2.2.3 and Table 4-5

22. PSAR, Section 4.2.2.2 and Table 4-4

23. PSAR, Section 4.5

24. PSAR, Section 5.1.1.2

25. PSAR, Section 5.1.4.3

26. PSAR, Sections 5.1.3 and 5.1.4

27. PSAR, Section 5.1.5.3

28. PSAR, Section 6

29. PSAR, Section 6.1.2

30. PSAR, Sections 6.2 and 6.3

31. PSAR, Section 14.2.2.4

32. PSAR, Section 7.1

33. Ibid

34. PSAR, Section 7.6.3

35. PSAR, Section 7.2.3.2

36. PSAR, Section 7.3.1

37. PSAR, Section 7.6.5

38. PSAR, Items 7.16 and 7.19 (Following Amendment No 5, Volume II)

39. PSAR, Section 7.5

40. PSAR, Section 8

41. PSAR, Section 9

42. PSAR, Section 9.1

43. PSAR, Section 9.3

44. PSAR, Section 9.2

45. PSAR, Sections 9.5, 9.6, 9.7 and 9.8

46. PSAR, Section 9.12

47. PSAR, Section 9.9

48. PSAR, Section 9.4

49. PSAR, Section 10

50. PSAR, Item 11.00 (Following Amendment No 9, Volume III)

51. PSAR, Section 10.2.5

52. PSAR, Section 9.7.2

53. PSAR, Section 11

54. PSAR, Item 11.1 (Following Amendment No 5, Volume II)

55. PSAR, Section 5.4.2

8.0 SAFETY ANALYSIS

Potential malfunctions or equipment failures have been analyzed to provide a safety evaluation of the Midland Plant. The results of these analyses show that the effects of the radioactivity released to the environment, even in the very unlikely event that such an accident should occur, are well within the guidelines established by the AEC (10 CFR Part 100)[1].

Two categories of malfunctions or equipment failures have been analyzed - those in which the fuel rods and reactor coolant system pressure boundary are protected and those in which one of these barriers to the release of fission products is not effective and engineered safeguards are required. The core and coolant boundary protection analysis analyzes those abnormalities that are either inherently terminated or require operation of the normal protection systems in order to maintain the integrity of the fuel rods and/or the reactor coolant system[2]. The standby safeguards analysis analyzes those accidents in which one or more of the nominal protection systems are not effective and therefore requires the operation of standby safety features[3]. The results of these analyses show that the effects of radioactivity releases to the environment for all credible malfunctions are well within the AEC safety guidelines (10 CFR 100).

Of the numerous malfunctions evaluated, a loss-of-coolant accident would be the most severe. Emergency core cooling systems are provided to prevent clad melting for entire spectrum of reactor coolant system failures ranging from the smallest leak to the complete severance of the largest reactor coolant pipe. The core cooling systems insure that core integrity will be maintained[4]. Either the reactor building sprays or the air recirculation and cooling system will maintain the integrity of the reactor building, assuring that the public will be protected against potential radiation hazards from the postulated accident[5]. Emergency electrical power is available on-site to insure operation of these systems even if all external sources of electric power to the plant are assumed to be unavailable at the time of the accident[6].

Results of the safety analyses show that, even in the event of a loss-of-coolant accident, no core melting will occur[5]. However, in order to demonstrate that the operation of a nuclear power station at the proposed site does not present a hazard to the general public, a "maximum hypothetical accident" has been analyzed assuming a release from the fuel of 100 percent of the noble gases, 50 percent of the halogens and 1 percent of the solids in the fission product inventory. Fifty percent of the halogens then further plate out. To have such a gross release of fission products, one must postulate a multitude of failures in the engineered safeguards systems[7], therefore, the accident is not regarded as credible. Even given these assumptions, however, the low leakage rate of the reactor building and the iodine removal spray system limit the potential radiation dose to the thyroid and the whole body to well below the AEC safety guideline values (10 CFR 100)[8].

References

1. PSAR, Section 14
2. PSAR, Section 14.1
3. PSAR, Section 14.2
4. PSAR, Section 6.1
5. PSAR, Section 14.2.2.3.2
6. PSAR, Section 8.2.3
7. PSAR, Section 14.2.2.4
8. PSAR, Table 14-1

9.0 COMPARISON WITH OTHER PWR

Appendix A is a comparative list of important design and operating parameters of the Midland Plant and of several other nuclear units which are scheduled to precede the Midland Plant into operation. The other units are Oconee Unit 1, Rancho Seco Unit 1, and Zion Units 1 and 2. The Midland, Oconee, and Rancho Seco units are being supplied by B&W; the Zion units are being supplied by Westinghouse.

The initial core rated power, nominal operating pressure, operating temperature, total coolant flow rate, average thermal output at rated power, average heat flux at rated power, minimum departure from nucleate boiling ratio (DNBR), and number of fuel assemblies are identical for the B&W units. The lesser number of control rod assemblies in the Midland units compared to the other B&W units is the result of a reduction in requirements for inserted control rod assemblies for equilibrium and transient xenon control. The differences in fuel burnups among the B&W plants is primarily the result of differences in plant operating requirements specified by the utilities involved.

A comparison of the number of coolant loops, coolant pumps, steam generators, and engineered safeguards features is also included. The loop arrangements and emergency core cooling systems capabilities for the B&W units are identical. Though the loop arrangements for the B&W and the Zion units are basically different, the emergency core cooling systems for all the units are generally similar.

The design of the Midland units compares favorably with the design of the other units presented. Similarities with other reactor building designs are compared in Section 3 of this summary. In addition, certain safety features of the Midland units are similar to those of the Zion and

Indian Point units. These include chemical reagent sprays and provision for charcoal filters, failed fuel detection, provisions to flood the reactor vessel cavity after a loss-of-coolant accident, penetration pressurization equipment, equipment to handle radiolysis of water after accidents and means to withstand mechanical forces and pressure transients in the vessel cavity.

The design of each of the units is based on information developed from operation of commercial and prototype pressurized water reactors over a number of years. The Midland Plant designs are based on this existing power reactor technology and have not been extended beyond the boundaries of known information or operating experience.

Prior to the time Midland Unit 1 is scheduled to go into commercial operation, more than ten operating years' experience is to be available from the eight B&W units of essentially identical design which are scheduled to precede it into operation.

In addition, the safety of the Midland units for operation at their design power level is further attested to by the fact that the ACRS in its letter to Chairman Seaborg of September 23, 1970, stated that the committee had completed its operating license review of Oconee Unit 1 and concluded that there is reasonable assurance that Oconee Unit 1 can be operated at power levels up to 2568 MW_t. The design of the Midland reactors is essentially identical to the Oconee 1 reactor design.

10.0 ENVIRONMENTAL MONITORING PROGRAM

10.1 General Radiological Surveillance

A preoperational environmental radiation survey(1) will be conducted to determine the existing levels of radioisotopes in the environment surrounding the plant, to note the use of the environment in the area and to sample those substances that are either directly consumed by man or involved in the ecological food chain of man.

Both the preoperational and the operational monitoring programs will sample air, water, aquatic life, including fish, and river sediment. External gamma exposure to man will be estimated by placing both film and thermoluminescent dosimeters in the environment. Discharges will be sampled and monitored before leaving the plant.

Gross beta analyses will be routinely performed on all samples. When gross beta counts exceed predetermined levels for each type of sample, however, additional specific isotope analyses will be performed. All river water samples will be analyzed for tritium and all air samples will be analyzed for I-131. Air samples will be collected on a weekly basis, and other materials will normally be collected monthly.

A reference area method of general radiological surveillance will be employed. This type of surveillance program utilizes a statistical comparison between sample analysis results of two sets of stations. One set of eight stations, commonly called the inner ring, will be located within about two miles from the plant, while another set of three stations, called background stations, will be located approximately 20 miles from the plant. Statistical differences between the survey results at the inner and outer rings will permit a determination as to whether any increase in radioactivity is of plant origin, and will permit an estimate to be made of any dose to man or buildup in radioactivity in the food chain. The survey will be sufficiently flexible to adjust to new environmental conditions and to take into account knowledge gained from the sample collection and analyses. Tentatively 5 additional air sampling stations and 12 additional thermoluminescent dosimeter stations are planned to be added at the time the plant goes into operation.

10.2 Aquatic Ecological Surveillance

An ecological survey is planned to detect possible effects of the cooling pond discharge or other plant wastewaters on the Tittabawassee River. Preoperational surveys will be conducted to provide baseline data for comparison with conditions after the plant is in operation.

Fish and bottom organisms populations will be sampled at each site as indices of ecological conditions, since they show not only direct response to environmental change but also reflect variations in productivity and other biotic parameters.

Sampling for the effects on the ecology of the Tittabawassee River will be done twice a year; in spring and in late summer or fall. These dates will probably be made to coincide with two of the dates set for radiological sampling. The spring sampling period will indicate the degree of change from the previous years and will sample the fauna at a time when maximum seasonal benthic diversity is expected.

The late summer or fall sampling will be done immediately after the most critical periods of low water and highest temperature and before sufficient time has passed for recovery from previous summer weather to mask the effects of these most adverse natural conditions.

To facilitate the ecological studies, ecological surveillance sites are, with the exception of one additional station upstream of the pond discharge, at sites which are designated for aquatic radiological surveillance. Four stations are upstream of the pond discharge and four stations are on the Tittabawassee River below the point of discharge.

It is anticipated that at least two years of preoperational data will be collected, and that the studies will be continued after the plant is in operation. The operational surveys will essentially be a continuation of the preoperational surveys in order to easily compare data.

10.3 Aquatic Radiological Surveillance

A special aquatic radiological survey is planned to determine (1) the background levels of radiation in the aquatic invertebrates and fish in the Tittabawassee River and in Saginaw Bay before the Midland Plant is in operation, (2) the sources, if any, of radionuclides discharged into the Tittabawassee River and Saginaw Bay before the plant is in operation, (3) the amounts and types of radionuclides in the Tittabawassee River and Saginaw Bay waters after the plant is in operation, and (4) the concentration factors and types of radionuclides found in aquatic invertebrates and fish in the Tittabawassee River and Saginaw Bay after the plant is in operation.

The radiological surveillance program will include analyses of samples of water, bottom sediment, bottom organisms and fish at each site. Except for the Saginaw Bay stations, samples will be collected four times a year, approximately on a quarterly basis. In Saginaw Bay, samples will be taken biannually (spring and fall) and will include, in addition to the other parameters, samples of the various species of resident waterfowl.

Three sampling stations are on tributaries above the Midland Plant, to provide data on upstream conditions for the reference analysis; five stations are on the Tittabawassee River below the plant; two stations are on other tributaries to the Saginaw River, which would not be affected by plant discharges, but are necessary to inventory radioactivity characteristics further downstream; one station is on the mouth of the Saginaw River, and approximately 15 stations are in Saginaw Bay. Samples will also be collected within the plant cooling and storage pond.

If the preoperational survey reveals any significant pattern in the radiological parameters, changes in the program, such as the elimination of particular samples or the inclusion of additional samples, may be considered.

Reference

1. PSAR, Amendment No 5, Item 2.1

11.0 TECHNICAL QUALIFICATIONS

11.1 Consumers Power Company

Applicant has over 48 years of experience in the operation of conventional electric generating plants. Applicant's General Office staff includes a number of persons associated with the Midland Plant project who have previous experience in the nuclear field, including experience in the design, construction and operation of applicant's 75 megawatt boiling water nuclear plant at Big Rock Point near Charlevoix, Michigan and the design and construction of applicant's 2,450 megawatt thermal Palisades Plant near Covert, Michigan.

The operating staff will consist of approximately 78 full-time employees[(1)]. The majority will come from existing generating plants on the Consumers Power Company system.

The major training[(2)] for supervisory personnel will take place at the Big Rock Point and Palisades Plants. Consumers Power Company personnel will participate in the design phases of the Midland Plant and may also receive simulator training at a B&W training facility.

11.2 Bechtel

Bechtel Corporation and its affiliate, Bechtel Company, have been retained by Consumers Power Company as Architect/Engineer and Constructor for the Midland project.

Working under the overall direction of Consumers Power Company and in close coordination with B&W, Bechtel will design or furnish, or both, all portions of the plant except the turbine generators and the equipment and fuel supplied by B&W. Bechtel will also construct the entire plant.

Bechtel has been continuously engaged in construction or engineering activities since 1898. For more than 20 years, Bechtel has been active in the fields of petroleum, power generation and distribution, harbor development, mining and metallurgy, and chemical and industrial processing.

Since the close of World War II, Bechtel has been responsible for the design of over 166 power generating units, representing more than 43 million kilowatts of thermal generating capacity, which includes units of the largest and most modern types. Of this number, more than 15 million kilowatts are produced by nuclear-fueled units.

For over 20 years, Bechtel has been engaged in the study, design and construction of nuclear installations. Its experience includes design or construction, or both, of such facilities as accelerators, nuclear research laboratories, hot cells, experimental reactors and nuclear fuel processing plants, as well as nuclear power plants. A summary of experience is listed in the application(3).

11.3 The Babcock & Wilcox Company (B&W)(4)

B&W's participation in the development of nuclear power dates from the Manhattan project. B&W's nuclear activities include applied research to develop fundamental data, design and manufacture of nuclear systems components, and design and manufacture of complete nuclear steam generating systems. Through the B&W Company's several divisions, a wide range of equipment for nuclear application is designed and manufactured. The B&W Company's major nuclear contracts, in addition to a substantial percentage of components for the nuclear Navy, have included:

- Indian Point Unit 1
- NS Savannah
- Advanced Test Reactor
- Oconee Nuclear Station Units 1, 2 & 3
- Three Mile Island Units 1 & 2
- Crystal River Unit 3
- Rancho Seco Unit 1
- Arkansas Nuclear One Station Unit 1
- Midland Units 1 & 2
- Davis-Besse Unit 1
- TVA Station (Undesignated) Units 1 & 2

With the exception of the last three contracts, all units have received construction permits.

References

1. Midland Plant - Preliminary Safety Analysis Report, Section 12.1
2. Midland Plant - Preliminary Safety Analysis Report, Section 12.2
3. General Information, Appendix D
4. General Information, Appendix C

12.0 QUALITY ASSURANCE AND QUALITY CONTROL

12.1 Introduction

Applicant has initiated an extensive Quality Assurance (QA) Program[1] to help assure that the Midland Plant is designed and constructed so that it will operate efficiently and reliably and without undue risk to the health and safety of the public and the plant personnel. The QA Program encompasses all phases of the design, construction, and operation. A program plan[2] has been developed outlining how the QA Program will be implemented. Overall responsibility for the program rests with applicant.

Bechtel will perform Quality Assurance of plant engineering, shop fabrication (including the nuclear steam system, except for fuel), field fabrication and construction. Bechtel is also responsible for providing Quality Control of receiving, storage, installation and erection at the plant site.

The Babcock & Wilcox Company has a Quality Assurance Program for the nuclear steam system. The scope of the B&W program includes the design, fabrication, shop testing and shipment of the components they furnish.

12.2 Consumers Power Company

Applicant will actively participate in a program or surveillance to assure that Bechtel and B&W implement their respective QA

Programs during the design, procurement and construction phases of this project. Applicant's surveillance program will include audits, inspections and witnessing of tests at vendor shops. Audits will also be performed on Bechtel home office activities and at the plant site during construction.

The direction and coordination of applicant's QA Program from design through construction is the responsibility of a Quality Assurance Engineer (QAE). The QAE will conduct or supervise audits and inspections of Bechtel home office, vendor shops and site audits. Site surveillance is the responsibility of the applicant's Construction Department Field QAE who functionally reports to the QAE. The Field QAE and QAE will be supported by engineers from the Engineering, Construction and Operating Departments and other specialists within the applicant's organization.

A comprehensive field testing program for the Midland Plant will be conducted to insure equipment and systems perform in accordance with design criteria. The applicant's Engineering Department is responsible for preparing preoperational test procedures and its Construction Department will be responsible for running the tests. Quality Assurance of preoperational testing will be performed by applicant's Field QAE and QAE.

Applicant is preparing written procedures containing internal instructions to employees with respect to performance of their responsibilities under applicant's QA Program.

12.3 Bechtel

The Bechtel Quality Assurance Program will be carried out in accordance with Bechtel's Nuclear Quality Assurance Manual to meet specific applicant requirements(2). This manual describes the overall program and identifies management and administrative procedures and individual responsibilities. General instructions, guidelines and checklists for inspections are contained in documents developed for specific phases of the QA program.

1. Bechtel Procurement Department Inspection Manual.
2. Bechtel Field Inspection Manual.
3. Bechtel Field Procurement Procedures.

Several levels of design review and approval are applied to significant design aspects of Bechtel work. These standard practices include:

1. Checking and review of design work by members of the Project Engineering team, other than those who originated the work.
2. Review and approval by the Originating Engineer's Design Group Supervisor.
3. Review and approval by the Project Engineer.
4. Review and/or approval by the appropriate Chief Engineer of certain key designs and calculations.

A design control checklist is prepared which identifies drawings, specifications and other data which shall be reviewed by

Chief Engineers or Technical Specialists under the Chief Engineers' direction. The Design Control Checklist is agreed on by the Project Engineer and the cognizant Chief Engineers soon after initiation of the project. When the items identified in the Design Control Checklist have been completed, the cognizant Chief Engineer will have the final review performed and execute a design control approval signifying that necessary review and monitoring work have been completed and the item is satisfactory from the standpoint of QA requirements.

Structures, systems and components to be covered by the QA Program are identified by a Q-List which is prepared by the Project Engineering team and reviewed and approved by Chief Engineers. Additional design control measures are implemented for items on the Q-List. The specific level of inspection and control afforded items on the Q-List are determined by the Project Engineering team through consultation with the Chief Engineers and Bechtel's Technical Specialists. Factors considered in establishing the degree of control include nature of the item, importance of the item to plant safety and reliability, previous experience with this or comparable items, capabilities of potential vendors or subcontractors, requirements of applicable codes or standards and provisions of the PSAR. Where required, Bechtel Engineering documents include specific procedures or requisites for the production and QA of the item or Bechtel will request their preparation by the organization responsible for manufacturing or erection.

In implementing the program in the construction phase, QA related responsibilities are assigned to the following personnel:

1. The Project Field Engineer supervises Quality Control (QC) inspection at the jobsite. In carrying out this assignment, he assigns qualified Field Engineers to perform QC inspections, he supervises the preparation of inspection checklists, verifies accuracy and completeness of inspection reports, ascertains that defects are removed and insures that repairs are carried out in accordance with applicable specifications, instructions and procedures.
2. The Quality Control Engineer reports to and assists the Project Field Engineer in carrying out QC inspection responsibilities. He normally is assigned responsibility for review of inspection reports, coordination, training and advising Field Engineers performing QC inspection assignments, coordination of testing laboratories and overall detailed execution of field inspection and maintenance of the field QC/QA files.
3. Field Engineer-Inspectors carry out the inspection assignments and are responsible for completing the appropriate inspection forms. Field Engineer-Inspectors function on a disciplinary basis, eg, mechanical equipment, civil-structural, electrical-power, instrumentation control, welding-metallurgy. The number of inspectors assigned depends upon the requirements of the variable

QC inspection workload and construction schedule. They have access to all design drawings, applicable codes and sampling and testing procedures pertaining to their inspection assignments.

4. The QA Engineer is the field representative of the Project Engineering team and receives supervision and technical support by the Project Engineer. However, he is assigned by and administratively reports to the Manager - Quality Assurance. He provides QA surveillance of engineering, QC and construction activities in the field. He reviews and accepts inspection reports, audits the permanent field QA/QC documentation files and monitors the overall QC program. The QA Engineer has the authority to stop the work for which Bechtel Corporation is prime contractor in the event of noncomformance with drawings, specifications and procedures established for structures, system and units on the Q-List. He serves as field contact with applicant's Quality Assurance organization and others concerned with Quality Assurance in the field.

12.4 <u>The Babcock & Wilcox Company</u>

B&W has a comprehensive Quality Assurance Program covering the design, procurement, fabrication and testing of nuclear steam systems and fuel for the Consumers Power Company Midland Plant[1]. The program is administered by a separate Quality Assurance organization whose responsibility is to assure the implementation of the program. The program establishes and maintains standards of quality through the development and implementation of requisite methods and procedures. In addition, the program is organized and administered so as to meet the provisions of the AEC's Quality Assurance Criteria for Nuclear Powerplants[3].

As a main contractor to Consumers Power Company, B&W is responsible, through its project manager, for developing the necessary specifications and/or associated purchase documents, which include Quality Control requirements, and for insuring that such requirements are followed for the shop fabrication of the nuclear components in B&W's scope of supply. B&W will also develop recommendations for site storage and installation of all such components.

The project manager is assisted in this effort by the manager of B&W-Nuclear Power Generation Department (NPGD) Quality Assurance, who reports directly to higher management to insure that he has sufficient organizational freedom to identify problems affecting quality and to insure that solutions are obtained. However, the project manager is responsible for coordinating the planning and scheduling of the B&W-NPGD Quality Assurance effort with other organizations and contractors involved in the Midland Plant Project. Further, B&W will provide erection consultation at the site throughout the period of installation of the nuclear steam system. B&W will maintain a Quality history file for the work that B&W and its subcontractors perform and, soon after a component is shipped to the site, will furnish to applicant copies of the portions of the file that apply to the component.

B&W's QA provisions for Midland Plant cover the design, procurement, fabrication and testing of the B&W nuclear steam systems, and fuel, including necessary Quality Control requirements. The policies and procedures specified in this Plan are coordinated with the Quality Assurance activities of other departments of the Power Generation Division.

References

1. Midland Plant PSAR, Appendix 1B
2. Midland Plant PSAR, Amendment 6
3. 10 CFR Part 50, Appendix B

13.0 COMMENTS ON ACRS REPORTS

In its reports of June 18, 1970 and September 23, 1970 to the Chairman of the Atomic Energy Commission favorably reviewing the Midland Plant for construction, the Advisory Committee on Reactor Safeguards (ACRS) identified certain areas for further consideration. These areas as they appear in the ACRS letters are listed below, together with applicant's comments thereon.

13.1 "A large volume of liquid chlorine is maintained in a refrig-
erated storage vessel about one mile from the Midland plant control
room. The applicant is continuing his study of the consequences of
a major accidental release of chlorine from this vessel. He has
included in his criteria for the design of the control room the ob-
jective of finding a practical method of maintaining the concentration
of chlorine in the control room atmosphere below the eight hour thres-
old limiting value (TLV) of 1 ppm for the most serious conceivable
chlorine accident. The Committee believes that adequate air purifi-
cation facilities should be provided in the control room ventilation
system to reduce chlorine concentration to the eight hour TLV of 1
ppm so that operators can work without respiratory equipment during
an extended chlorine emergency. This matter should be resolved
during construction in a manner satisfactory to the Regulatory Staff."

Answer:

Applicant will review this design during construction with the Regulatory Staff. A system design will provide for supplying air to the control room through a filtration system so as to meet a chlorine concentration criterion of 1 ppm and eliminate the necessity for respiratory equipment.

13.2 "The applicant has stated that he will provide additional evidence obtained by improved multi-node analytical techniques to assure that the emergency core cooling system is capable of limiting core temperatures to the limits established at present. He will also make appropriate plant changes if the further analysis demonstrates that such changes are required. This matter should be resolved during construction in a manner satisfactory to the Regulatory Staff. The Committee wishes to be kept informed."

Answer:

B&W analyzed the ability of the Midland emergency core cooling systems to limit fuel clad temperatures to acceptable values following a loss-of-coolant accident and reported the results of these analyses in the PSAR. Recent work by AEC consultants raised a question about whether the analytical techniques used in the analyses reported in the PSAR were detailed enough.

CRAFT, B&W's multinode computer code for analyzing loss-of-coolant accidents, will be used to reevaluate the Midland emergency core cooling system (ECCS) design. This work will be completed in time to make any necessary changes in the ECCS design, should the analysis show that the current design will not limit the fuel clad temperature to acceptable values.

1 13.3 "The safety injection system for the Midland plant is actuated by either low reactor pressure or high containment pressure signals. However, of these two, the reactor is tripped only by the low reactor pressure signal. The Committee believes that provision also should be made to trip the reactor by the high containment pressure signal."

Answer:

2 A diverse backup to the low-reactor-coolant-system-pressure
3 trip signal such as a power-flow, low-flow, or high-reactor-building-
4 pressure trip signal will be provided for in the design of the Midland
5 reactors.

1 13.4 "The applicant plans to develop more detailed criteria for the installation of protection and emergency power systems together with appropriate procedures to maintain the physical and electrical independence of the redundant portions of these systems. The Committee believes that these criteria and procedures should be reviewed and approved by the Staff prior to actual installation."

Answer:

2 Applicant will review the detailed criteria and procedures

3 with the Staff and obtain its approval prior to actual installation.

1 13.5 "The applicant considers the possibility of melting and subsequent disintegration of a portion of a fuel assembly because of flow starvation, gross enrichment error, or from other causes to be remote. However, the resulting effects in terms of local high temperature or pressure and possible initiation of failure in adjacent fuel elements are not well known. Appropriate studies should be made to show that such an incident will not lead to unacceptable conditions."

Answer:

2 B&W has completed a study of fuel and clad temperatures and
3 internal pressures for a fuel rod undergoing sustained departure
4 from nucleate boiling due to flow starvation. The results of that
5 study demonstrated that such an incident would not lead to unaccept-
6 able conditions and were submitted to Division of Reactor Licensing
7 (DRL) in B&W Topical Report, BAW-10014, "Analysis of Sustained
8 Departure From Nucleate Boiling Operation."

9 A B&W study to examine the effects of misplacing a fuel
10 pellet, a fuel rod or a fuel assembly will be completed during 1971
11 and the results will be reported to the DRL staff.

1 13.6 "The Committee believes that consideration should be given to the utilization of instrumentation for prompt detection of gross failure of a fuel element."

<u>Answer</u>:

2 The Midland Plant will employ instrumentation to promptly detect
3 gross failure of a fuel element. This instrumentation will be similar
4 to that approved for the applicant's Palisades Plant. The instrumenta-
5 tion will continuously monitor the gamma radioactivity in the reactor
6 coolant after a sufficient decay time to reduce the concentration of
7 very short-lived, nonfission product radionuclides such as N-16.

1 13.7 "The Committee has commented in previous reports on the development of systems to control the buildup of hydrogen in the containment which might follow in the unlikely event of a major accident. The applicant proposes to make use of a technique of purging through filters after a suitable time delay subsequent to the accident. However, the Committee recommends that the primary protection in this regard should utilize a hydrogen control method which keeps the hydrogen concentration within safe limits by means other than purging. The capability for purging should also be provided. The hydrogen control system and provisions for containment atmosphere mixing and sampling should have redundancy and instrumentation suitable for an engineered safety feature. The Committee wishes to be kept informed of the resolution of this matter."

<u>Answer</u>:

2 Applicant has accepted the Committee recommendation to utilize
3 a hydrogen control method other than purging, in accordance with the
4 above. The method expected to be employed will utilize hydrogen-
5 oxygen recombiners.

13.8 "The Committee recommends that the applicant accelerate the study of means of preventing common failure modes from negating scram action and of design features to make tolerable the consequences of failure to scram during anticipated transients. The applicant stated that the engineering design would maintain flexibility with regard to relief capacity of the primary system and to a diverse means of reducing reactivity. This matter should be resolved in a manner satisfactory to the Regulatory Staff during construction. The Committee wishes to be kept informed."

Answer:

B&W has completed a study of common failure modes. The results of this study have been submitted to DRL in B&W Topical Report, BAW-10019, "Systematic Failure Study of Reactor Protections Systems."

B&W has completed a study of anticipated operational transients without trip and reported the results to DRL. Applicant has been advised that the Regulatory Staff is considering issuing guidelines for the further study of operational transients without trip. B&W is waiting for DRL to issue the guidelines before proceeding further.

The Midland Plant design does not preclude the possibility of increasing the primary system relief capacity or of providing diverse means of reducing reactivity. However, the common failure modes and anticipated transient without trip studies completed to date do not indicate the need for either revision to the reactor system design.

13.9 "Other problems related to large water reactors have been identified by the Regulatory Staff and the ACRS and cited in previous ACRS reports. The Committee believes that resolution of these items should apply equally to the Midland Plant Units 1 & 2."

<u>Answer</u>:

The other matters referred to in this section of the ACRS letter are discussed in Appendix C, "Research and Development Programs of Interest to ACRS First Identified in Earlier Cases."

1 13.10 "The Committee believes that the proposed system of reboilers will provide substantial additional assurance that leakage of primary system radioactivity into the export steam can be maintained at an extremely low and insignificant level and that the export steam can be maintained essentially at natural background levels. The detailed procedures for monitoring and control of the reboiler system should be developed during construction in a manner satisfactory to the Regulatory Staff. The Committee wishes to be kept informed."

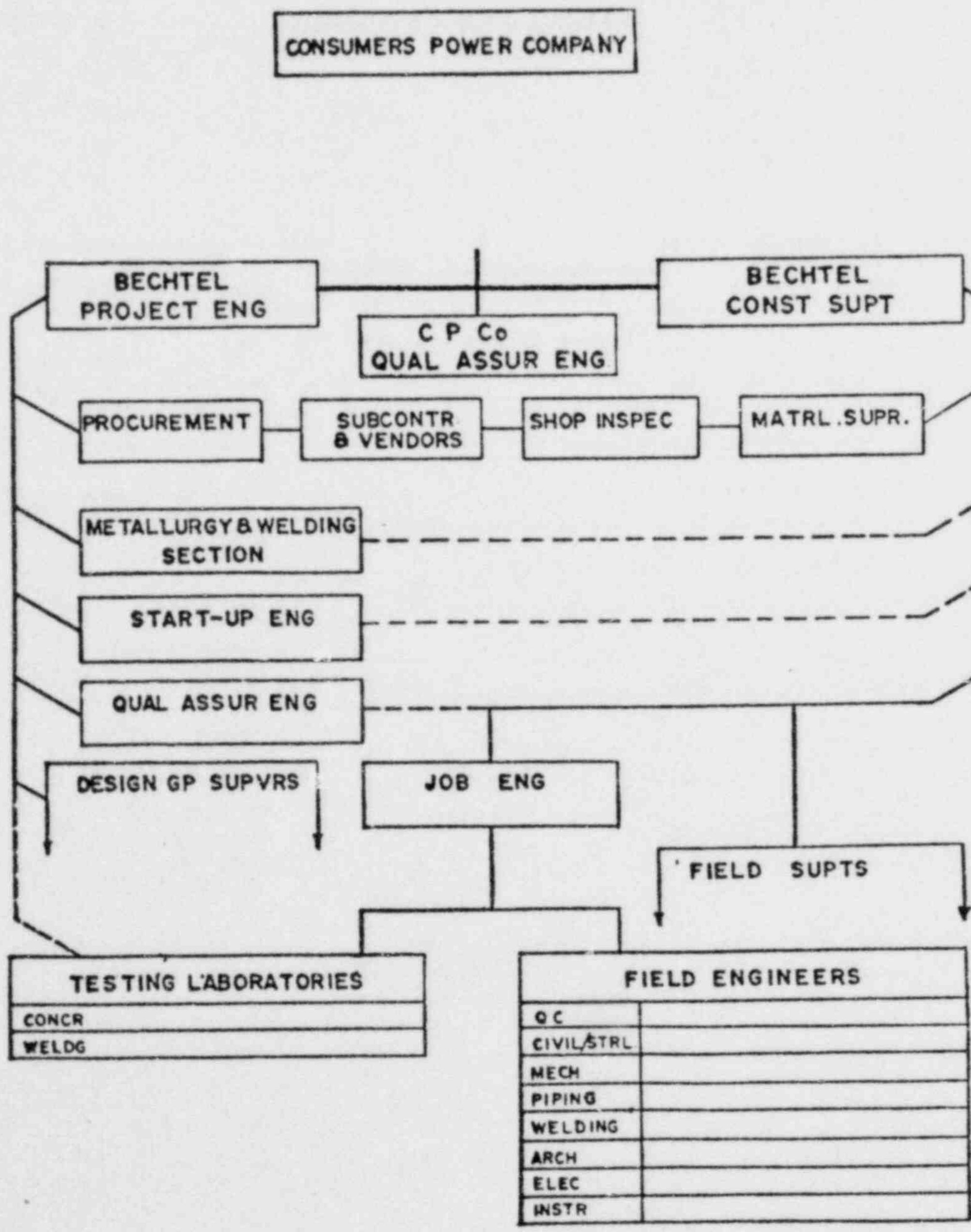
Answer:

2 Applicant will develop detailed procedures for monitoring and
3 control of the reboiler system. These will be developed during con-
4 struction in a manner satisfactory to the Staff.

FIGURE 1-7

MIDLAND PLANT UNITS 1 AND 2
NUCLEAR POWER STATION
PROJECT QUALITY ASSURANCE ORGANIZATION

CHART BELOW SHOWS RELATIONSHIP BETWEEN
ENGINEERING · PROCUREMENT · AND CONSTRUCTION.



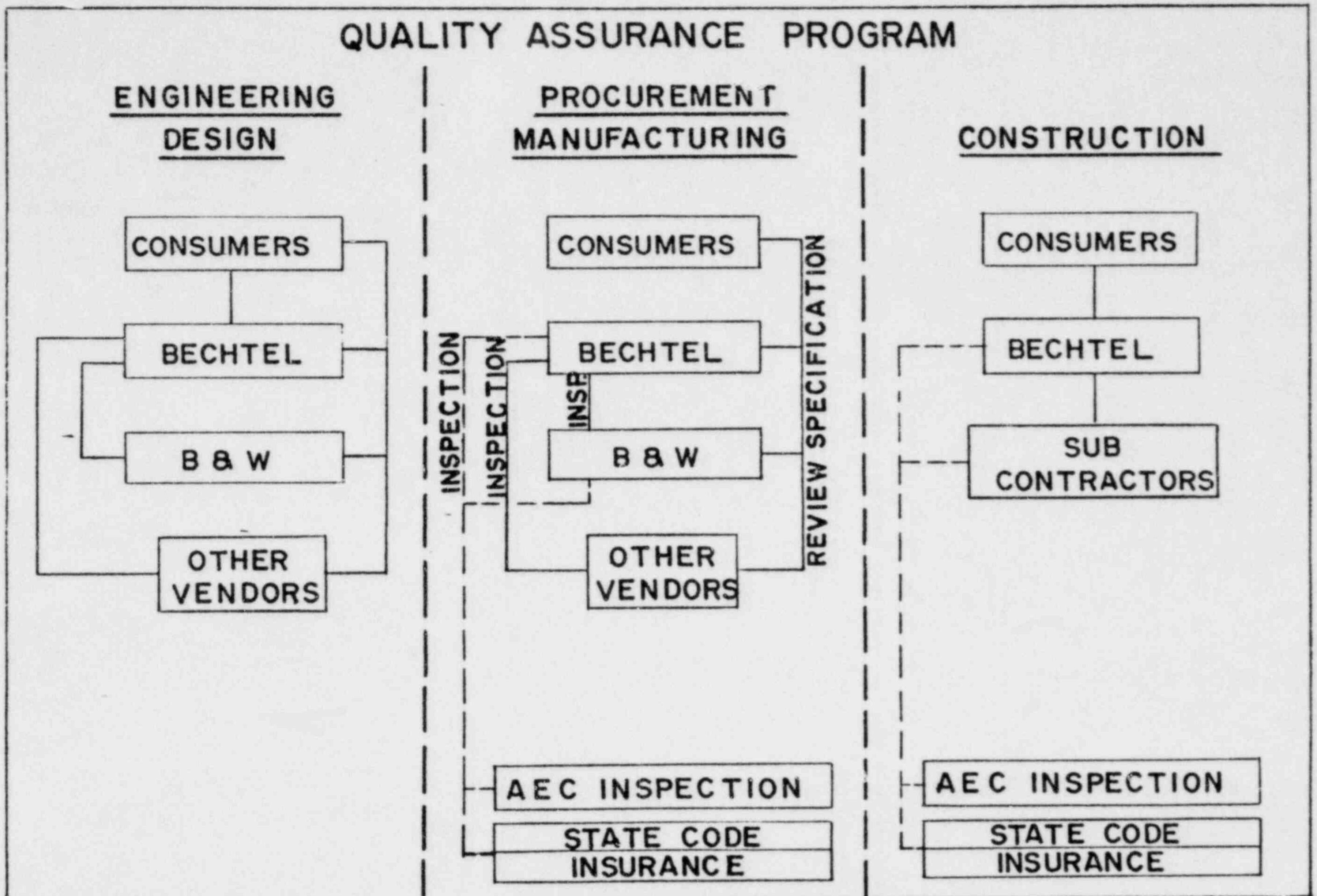

QUALITY ASSURANCE PROGRAM
ENGINEERING DESIGN
PROCUREMENT MANUFACTURING
CONSTRUCTION
CONSUMERS
BECHTEL
B & W
OTHER VENDORS
CONSUMERS
BECHTEL
B & W
OTHER VENDORS
INSPECTION
INSPECTION
INSP
REVIEW SPECIFICATION
AEC INSPECTION
STATE CODE
INSURANCE
CONSUMERS
BECHTEL
SUB CONTRACTORS
AEC INSPECTION
STATE CODE
INSURANCE

FIGURE -2

14.0 FINANCIAL QUALIFICATIONS

Applicant has estimated that the total cost of the Midland Plant, including the first-core fuel, is \$394,827,000[1]. All items included in the categories comprising the plant cost estimate are the same as those which would be included in the relevant electric plant and nuclear fuel inventory accounts of the Federal Power Commission's Uniform System of Accounts prescribed for Public Utilities and Licensees (Class A and Class B).

Applicant will finance the Midland Plant as an integral part of its normal construction program, using funds internally generated and from the sale of securities, in the same general manner as it finances other plant additions.

Reference

1. General Information, Page 6, as Amended by Amendment No 13

15.0 COMMON DEFENSE AND SECURITY

Applicant is a Michigan corporation and conducts its business solely within the State of Michigan. Its directors and principal officers are all citizens of the United States. The Company is not owned, controlled or dominated by an alien, a foreign corporation or foreign government[1].

The Company has agreed that it will not permit any individual to have access to restricted data until the Civil Service Commission has made an investigation and report to the AEC on the character, associations and loyalty of such individual, and the AEC has determined that permitting such person to have access to restricted data will not endanger the common defense and security[2].

As stated in Section 57 of the Atomic Energy Act of 1954, as amended, and 10 CFR, Part 70, Section 70.42, the Company may not transfer special nuclear material except as authorized by the AEC. The Company will, as a licensee, be subject to AEC regulations requiring accountability for and physical protection of fissionable material[3].

References

1. General Information, Paragraph (d)
2. General Information, Paragraph (i)
3. 10 CFR 70, Paragraphs 70.51 Through 70.56; 10 CFR 73

16.0 CONCLUSION

On the basis of the foregoing and application, the applicant respectfully submits that:

1. Applicant has described the proposed design of the Midland Plant facilities, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public.

2. The application, as amended, identifies the technical and design information necessary to complete the final safety analysis. Such information can reasonably be left for later consideration and will be supplied in the final safety analysis report.

3. Safety features which require further research and development, and the research and development programs to be carried out, are identified in Section 1.5 of the PSAR. The research and development program is reasonably designed to resolve any safety questions associated with such features at or before the latest dates stated in the application for completion of construction of the facilities.

4. Taking into consideration the characteristics of the site and environs and the proposed design of the Midland Plant

facilities, and the site criteria contained in 10 CFR, Part 100, such facilities can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

5. Applicant is technically qualified to design and construct the proposed facilities.

6. Applicant is financially qualified to design and construct the proposed facilities.

7. The issuance of permits for the construction of the proposed Midland Plant facilities will not be inimical to the common defense and security of the United States or to the health and safety of the public.

APPENDIX A

COMPARISON OF PWR DESIGN PARAMETERS[1]

	Midland Unit 1 or 2	*Rancho Seco Unit 1	**Oconee Unit 1	***Zion Unit 1 or 2
Initial Core Rated Power, MW_t	2452	2452	2452	3250
Nominal Operating Pressure, Psia	2200	2200	2200	2250
Nominal Coolant Inlet Temperature, F	555	555	555	539
Average Coolant Temperature Rise in Core, F	50	50	50	69
Total Coolant Flow Rate, Lb/Hr	131.3×10^6	131.3×10^6	131.3×10^6	135×10^6
Average Thermal Output at Rated Power, kW/Ft	5.4	5.4	5.4	6.7
Maximum Thermal Output at Design Overpower, kW/Ft	19.2	19.2	19.2	21.2
Average Heat Flux at Rated Power, Btu/Hr-Ft^2	163,725	163,725	163,725	207,000
Minimum DNBR at Rated Power	2.21(W-3)	2.21(W-3)	2.21(W-3)	1.81(W-3)
Minimum DNBR at Design Overpower	1.71(W-3)	1.71(W-3)	1.71(W-3)	1.30(W-3)
Number of Fuel Assemblies	177	177	177	193
Equilibrium Core Average Fuel Burnup, MWd/MTU	27,490	28,200	28,200	33,000
Number of Control Rod Assemblies	57	69	69	61
Total Control Rod Worth, % $\Delta k/k$	8.0	10.0	10.1	7
Number of Reactor Coolant Loops	2	2	2	4
Number of Reactor Coolant Pumps	4	4	4	4
Number of Steam Generators	2	2	2	4
Number of High Head Safety Injection Pumps	2	2	2	2
Number of Low Head Safety Injection Pumps	2	2	2	2
Number of Core Flooding Tanks	2	2	2	4
Number of Reactor Building Air Coolers	4	4	3	5
Number of Reactor Building Spray Pumps	2	2	2	3

*As Proposed for the Rancho Seco Unit 1 FSAR (50-312)
**As Extracted From the Oconee Unit 1 FSAR (50-269)
***As Extracted From the Zion PSAR (50-295 and -304)

(1) Note: Differences between this Appendix and Midland PSAR, Table 1-2, are due to the use of more recent information than was available at the time Table 1-2 was prepared.

APPENDIX B

FIGURES

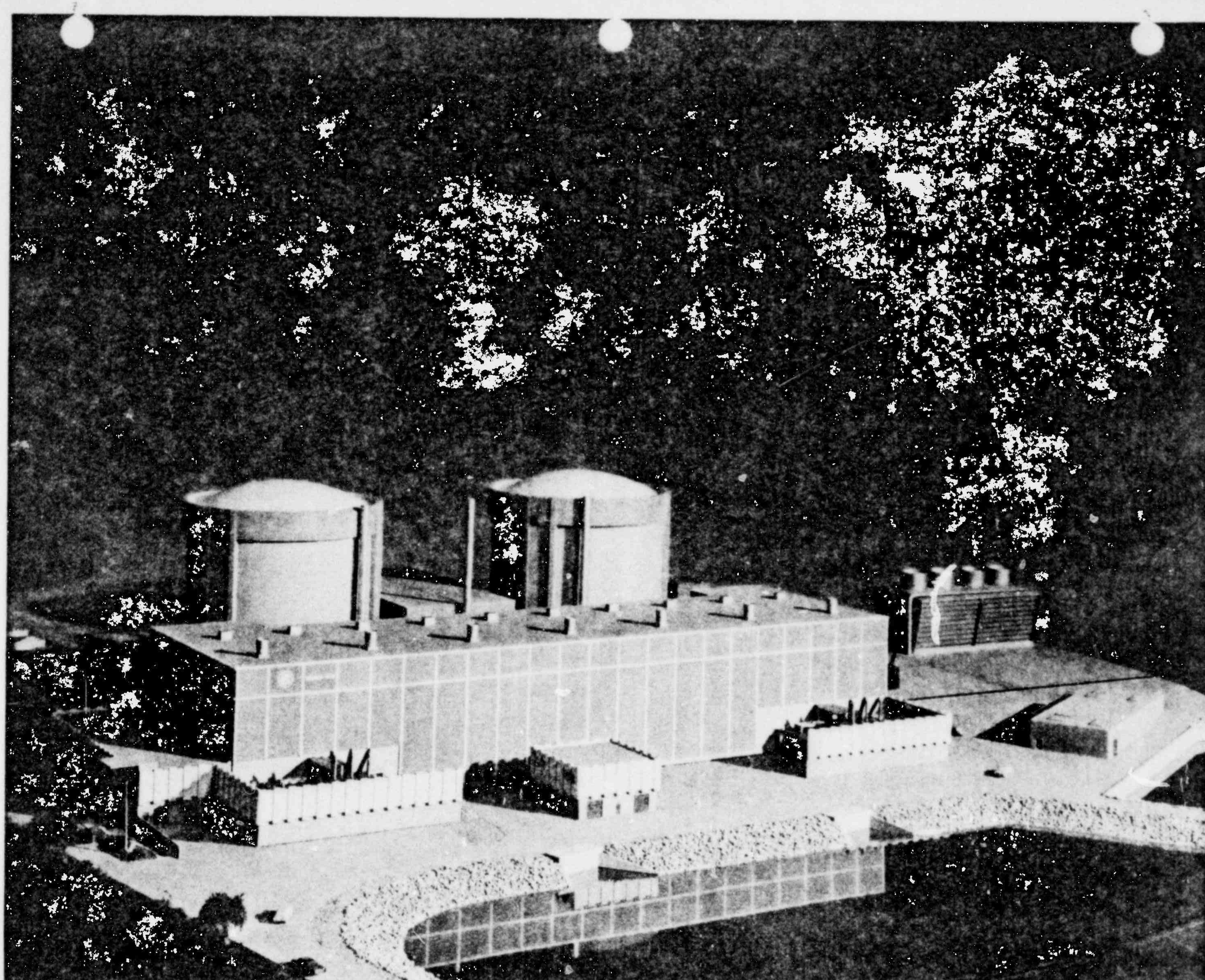
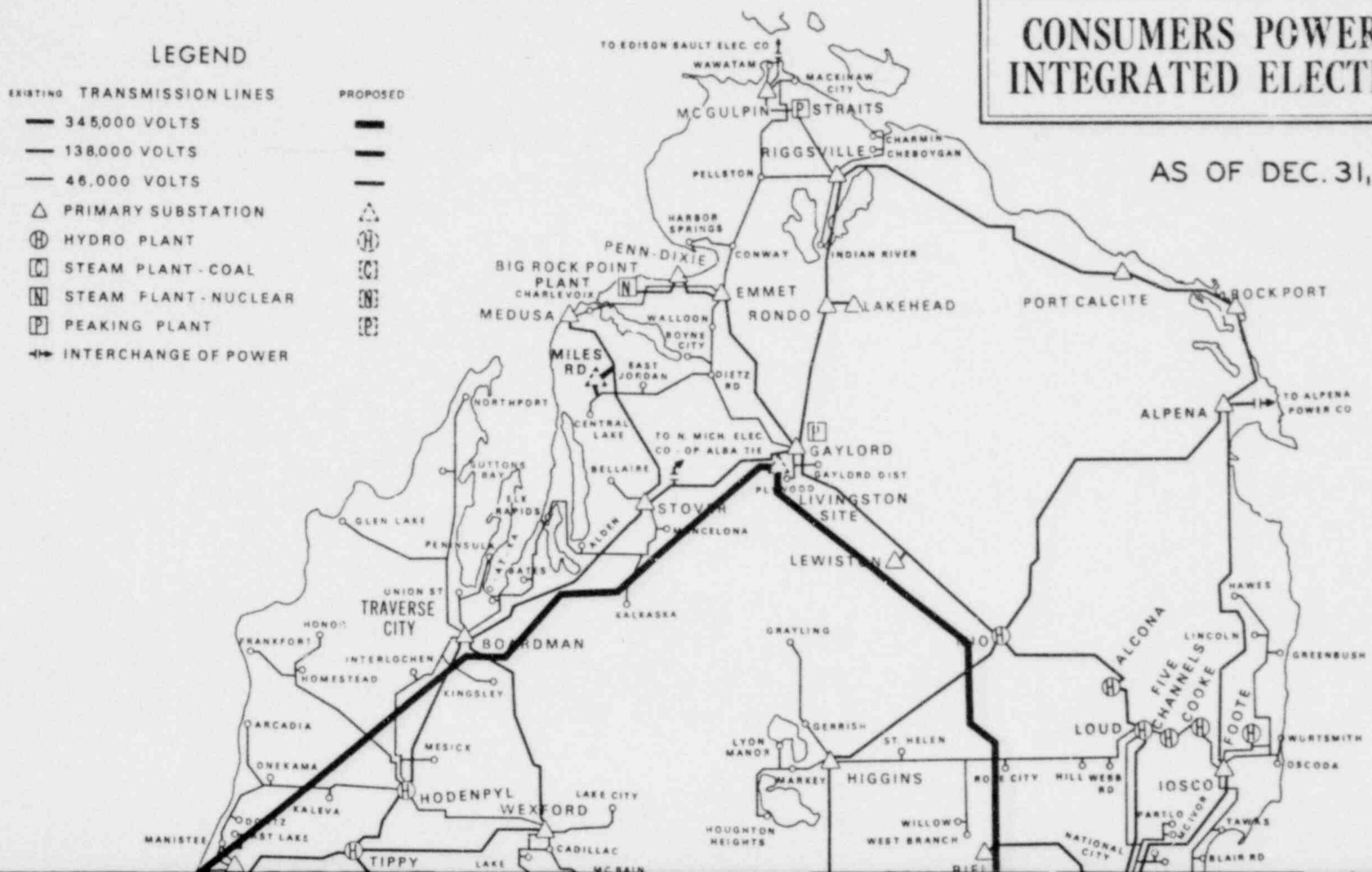


FIGURE I

CONSUMERS POWER COMPANY
INTEGRATED ELECTRIC SYSTEM

AS OF DEC. 31, 1969



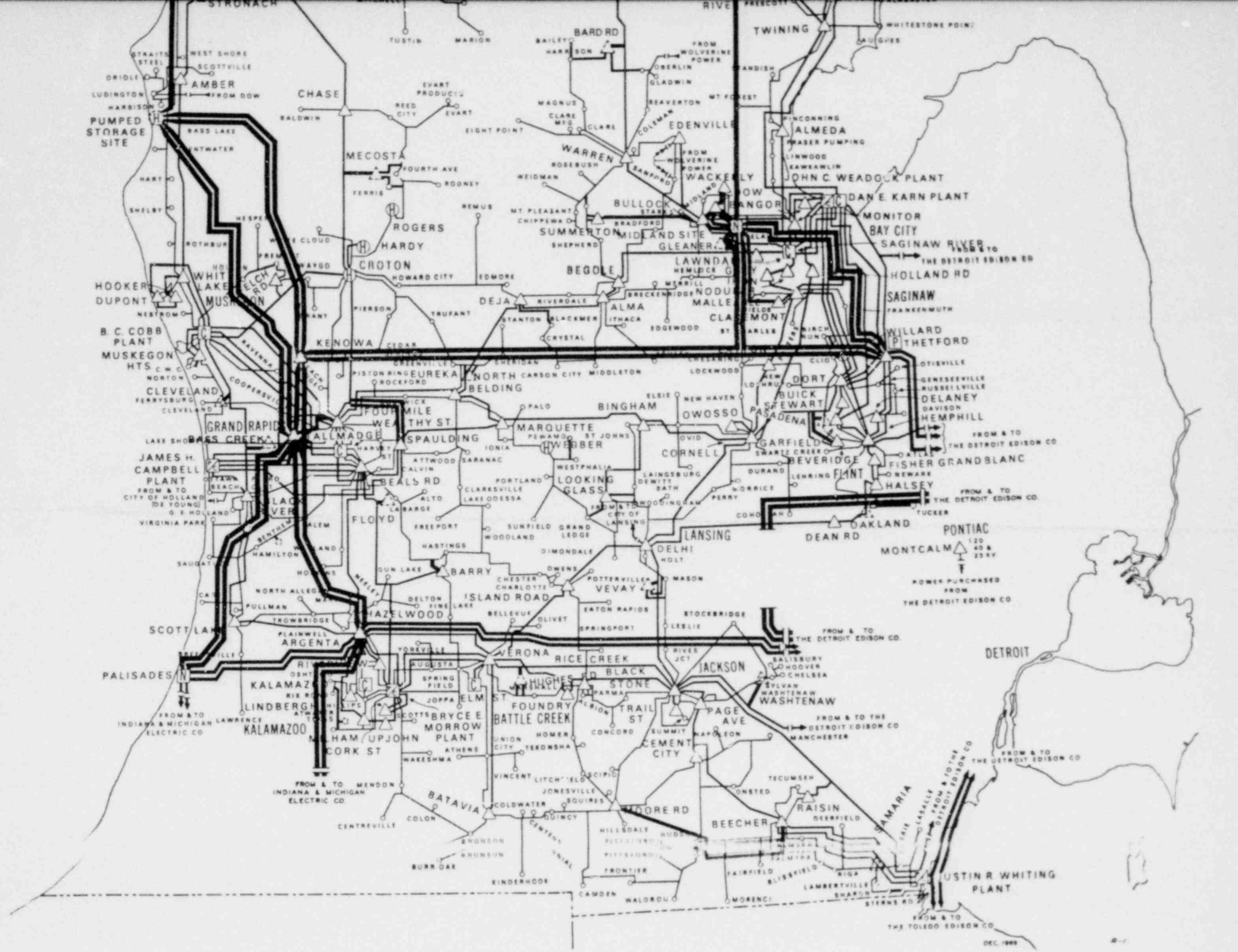
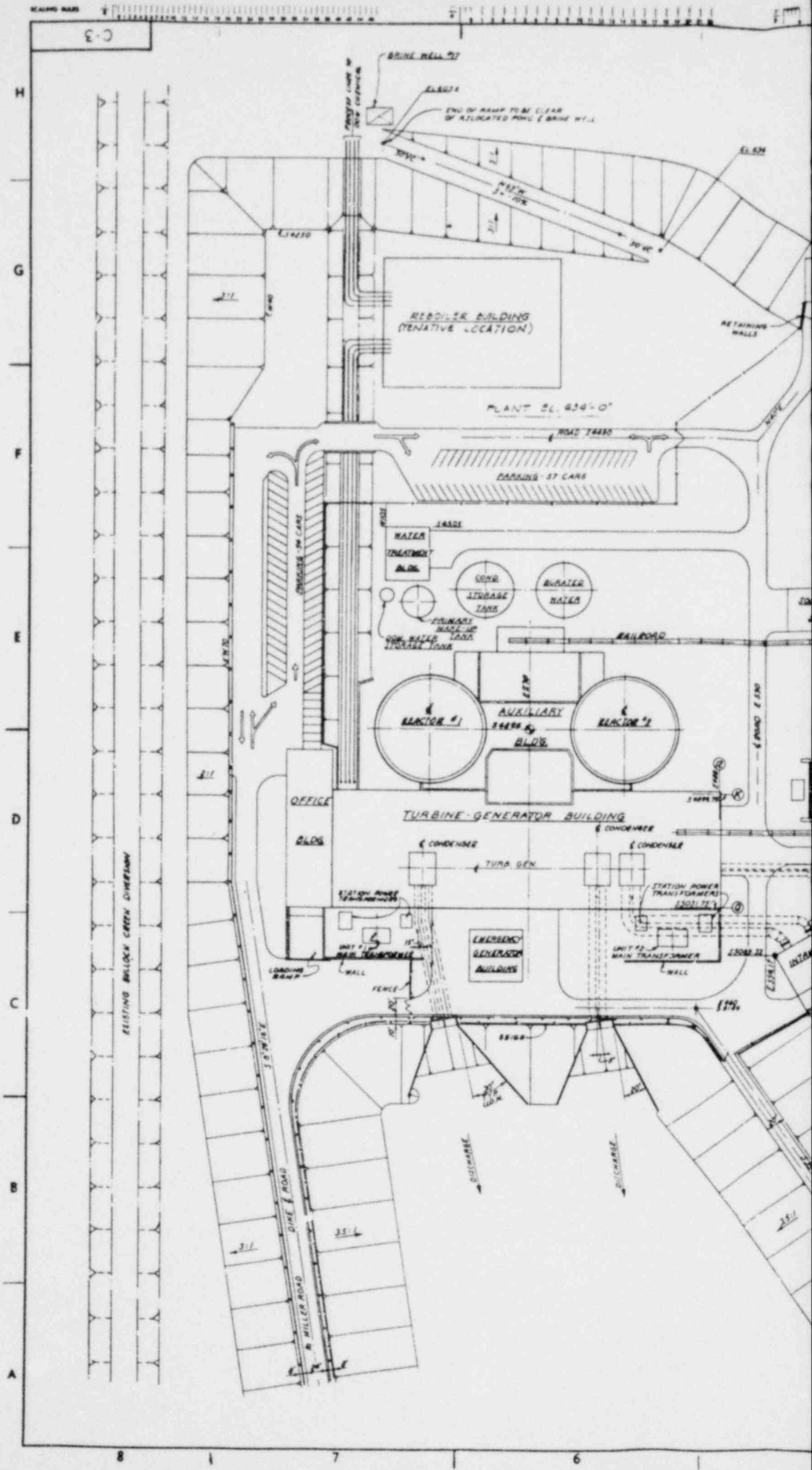
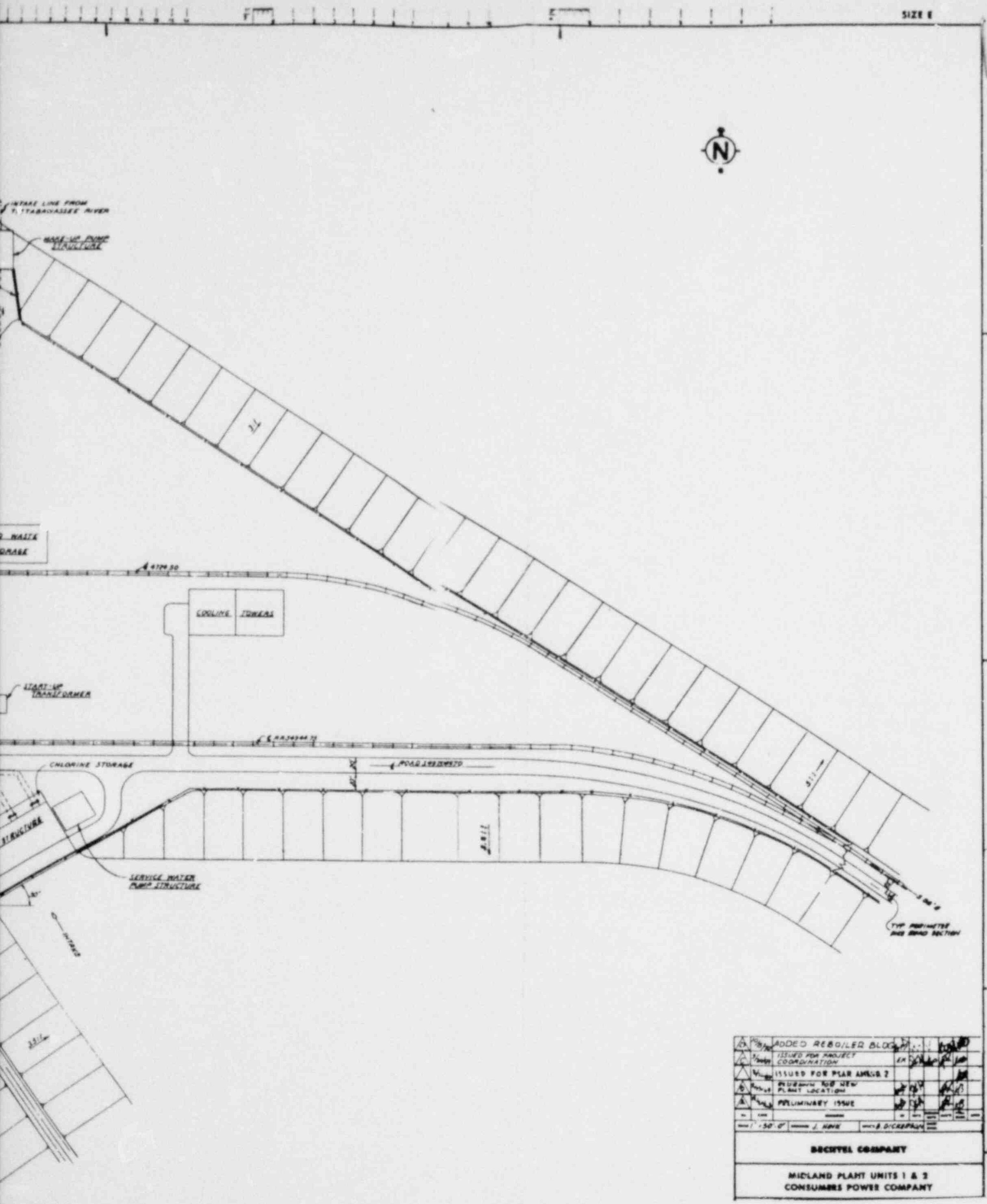


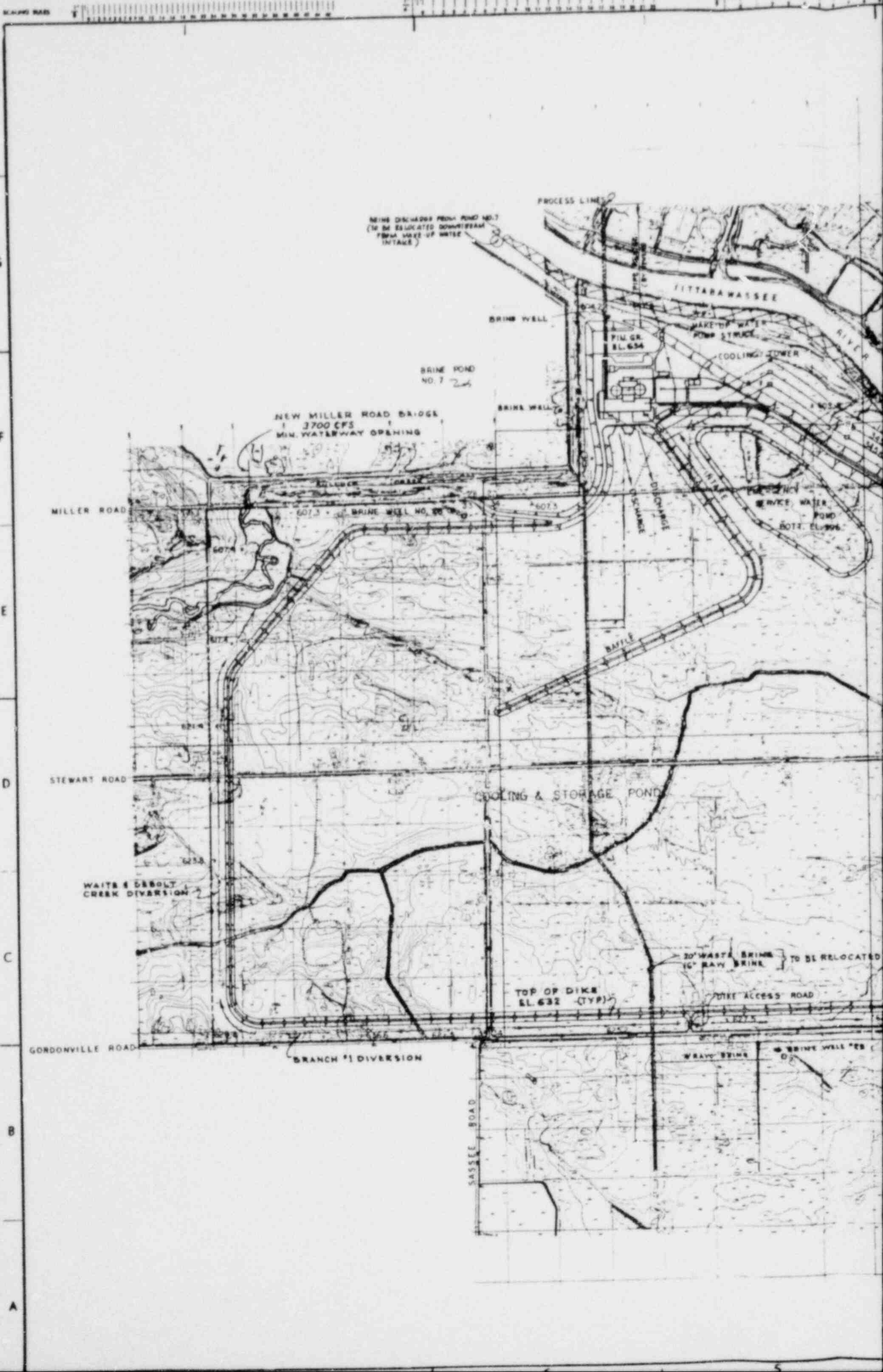
FIGURE 2


C-3
BRINE WELL #7
REBOILER BUILDING
(TENATIVE LOCATION)
RETAINING WALLS
PLANT EL. 634'-0"
PARKING - 57 CARS
WATER TREATMENT BLDG.
COND STORAGE TANK
BORATED WATER
PRIMARY MAKE-UP TANK
RAILROAD
REACTOR #1
AUXILIARY BLDG.
REACTOR #2
OFFICE BLDG.
TURBINE-GENERATOR BUILDING
℄ CONDENSER
TURB GEN
STATION POWER TRANSFORMERS
UNIT #2 MAIN TRANSFORMER
WALL
LOADING RAMP
FENCE
EMERGENCY GENERATOR BUILDING
DISCHARGE
DISCHARGE
EXISTING BULLOCK CREEK DIVERSION
DIKE ℄ ROAD
N. MILLER ROAD
H
G
F
E
D
C
B
A
8
7
6

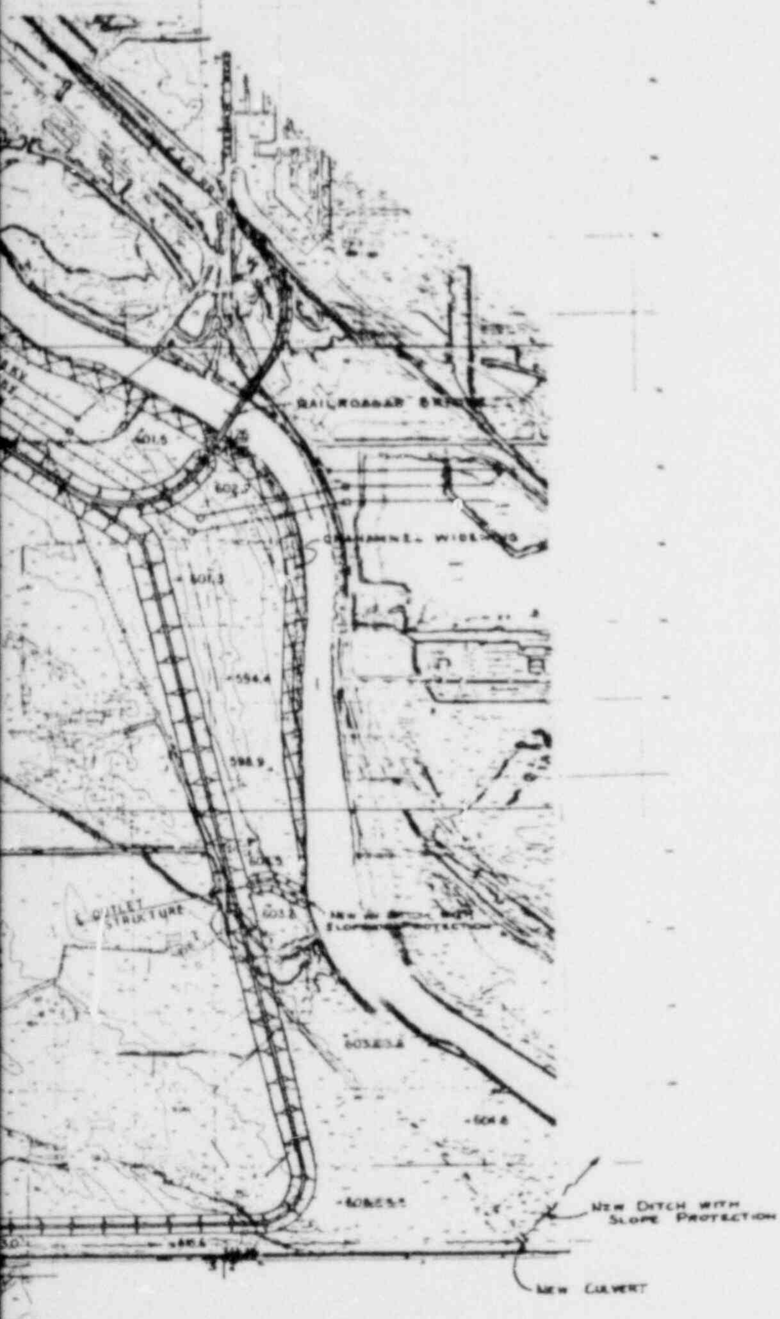


SIZE E
INTAKE LINE FROM TITTABAWASSEE RIVER
MAKE-UP PUMP STRUCTURE
WASTE STORAGE
COOLING TOWERS
START-UP TRANSFORMER
CHLORINE STORAGE
SERVICE WATER PUMP STRUCTURE
TYP PERIMETER DIKE ROAD SECTION
ADDED REBOILER BLDG
ISSUED FOR PROJECT COORDINATION
ISSUED FOR PSAR AMEND 2
PRELIMINARY ISSUE
BECHTEL COMPANY
MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

FIGURE #3



H
G
F
E
D
C
B
A
PROCESS LINES
TITTABAWASSEE
RIVER
BRINE WELL
COOLING TOWER
BRINE POND NO. 7
NEW MILLER ROAD BRIDGE
3700 CFS
MIN. WATERWAY OPENING
MILLER ROAD
BAFFLE
STEWART ROAD
COOLING & STORAGE POND
WAITE & DEBOLT CREEK DIVERSION
TOP OF DIKE EL. 632 (TYP)
DIKE ACCESS ROAD
TO BE RELOCATED
GORDONVILLE ROAD
BRANCH #1 DIVERSION
SASSEE ROAD



SIZE E

NOTES:

1. BOTTOM ELEVATION = 615 EXCEPT WHERE EXISTING GROUND IS LOWER
2. WATER SURFACE ELEV = 627 MAX., 618 MIN.
3. APPROX. WATER SURFACE = 880 ACRES

LEGEND

———	PROPERTY LINE
•	EXISTING BRINE WELL
(crosshatch)	CHANNEL WIDENING
• 605.0	SPOT ELEVATIONS

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

SITE PLAN

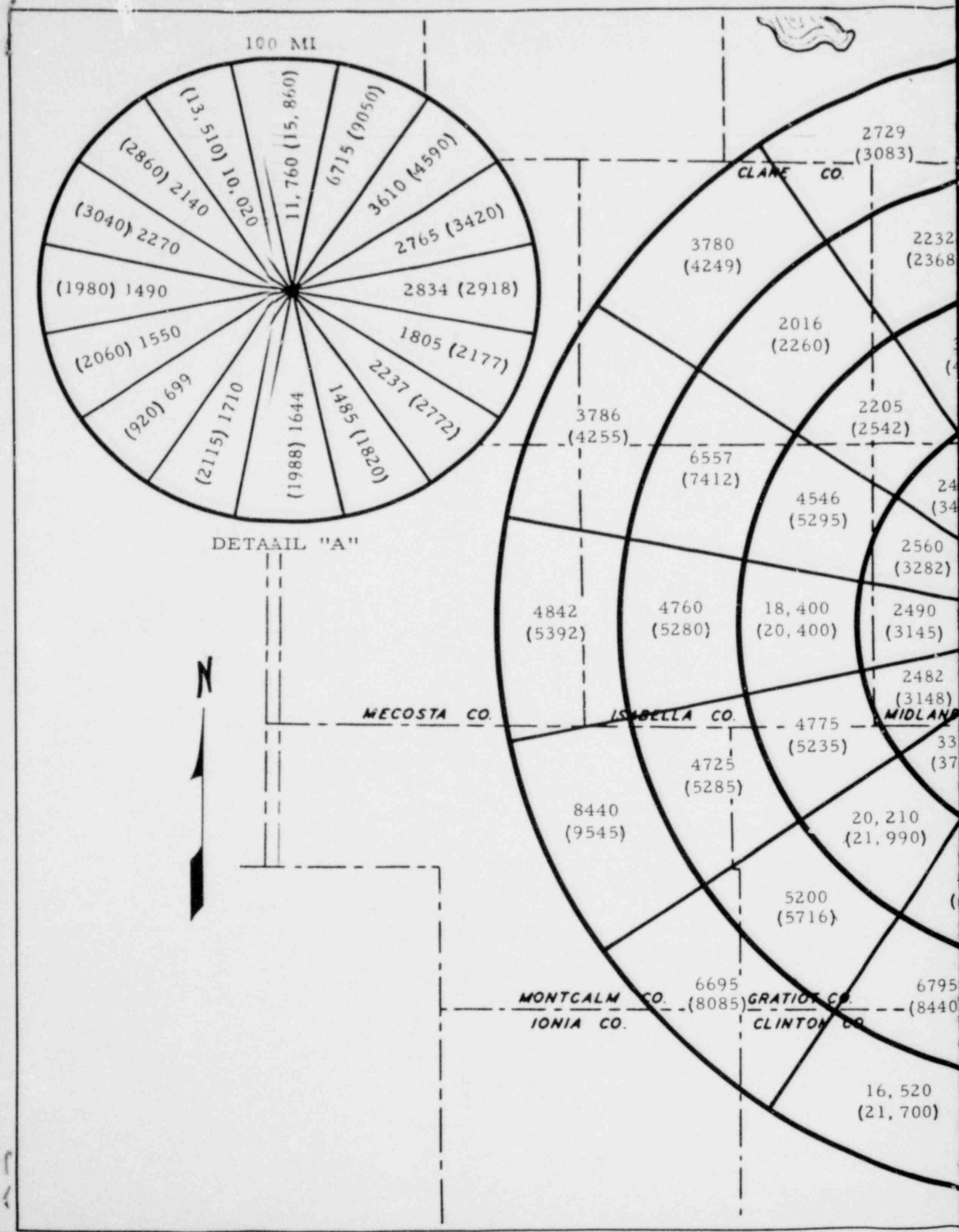
FIGURE #4


N
LOW POPULATION ZONE
MIDLAND
CITY LIMITS
500 M
REACTO
SITE
MILLER RD
PATTERSON RD
POSEYVILLE RD
S STEWART RD
GORDONVILLE RD

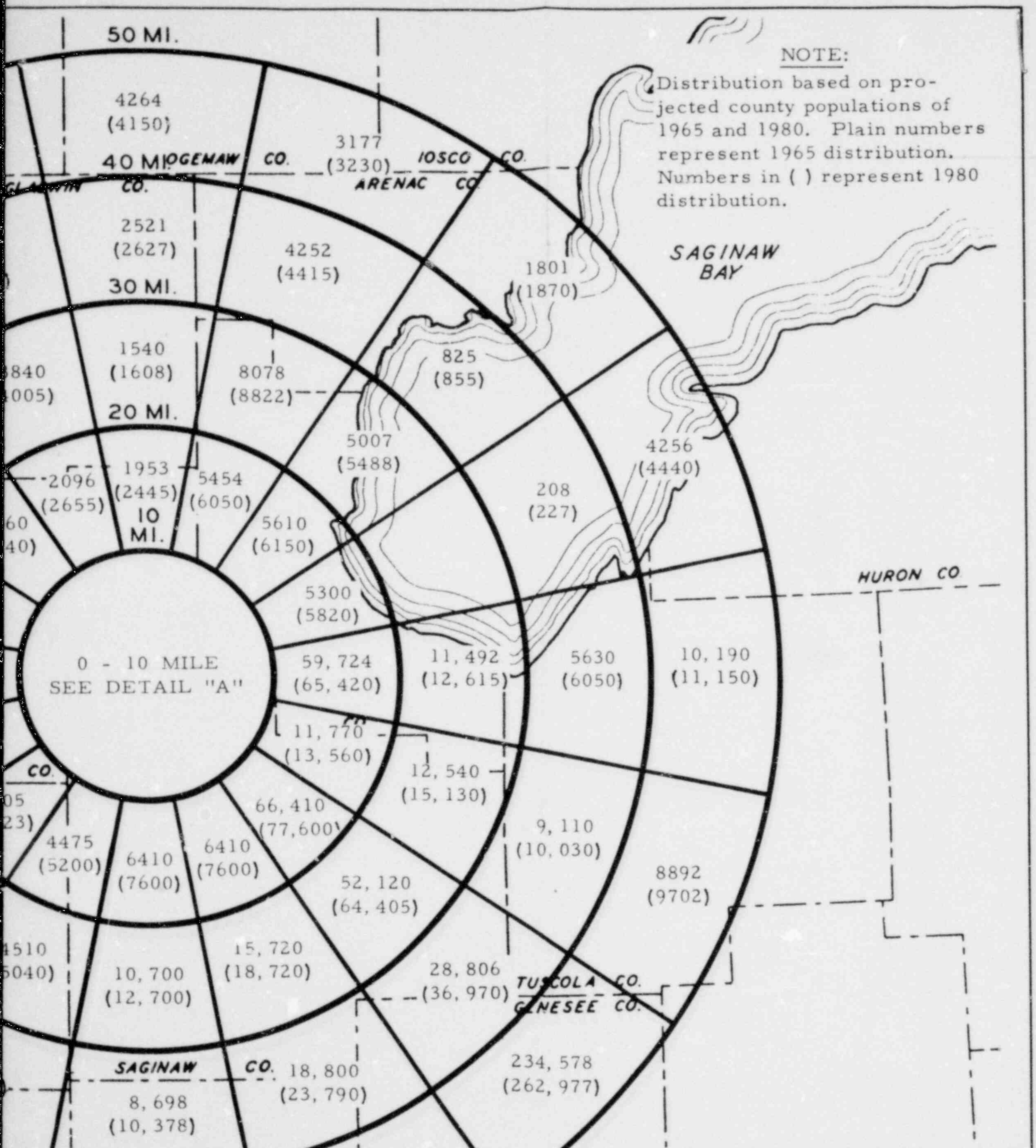
MIDLAND PLANT
CONSUMERS POWER COMPANY

PLANT SITE AND ADJACENT AREA

FIGURE # 5



100 MI
11,760 (15,860)
6715 (9050)
3610 (4590)
2765 (3420)
2834 (2918)
1805 (2177)
2237 (2772)
1485 (1820)
(1988) 1644
(2115) 1710
(920) 699
(2060) 1550
(1980) 1490
(3040) 2270
(2860) 2140
(13,510) 10,020
DETAAIL "A"
N
2729
(3083)
CLARE CO.
3780
(4249)
2232
(2368
2016
(2260)
3786
(4255)
2205
(2542)
6557
(7412)
4546
(5295)
2560
(3282)
4842
(5392)
4760
(5280)
18,400
(20,400)
2490
(3145)
2482
(3148)
MECOSTA CO.
ISABELLA CO.
4775
(5235)
4725
(5285)
8440
(9545)
20,210
(21,990)
5200
(5716)
6695
(8085)
6795
(8440
MONTCALM CO.
GRATIOT CO.
IONIA CO.
CLINTON CO.
16,520
(21,700)



MIDLAND PLANT
CONSUMERS POWER COMPANY

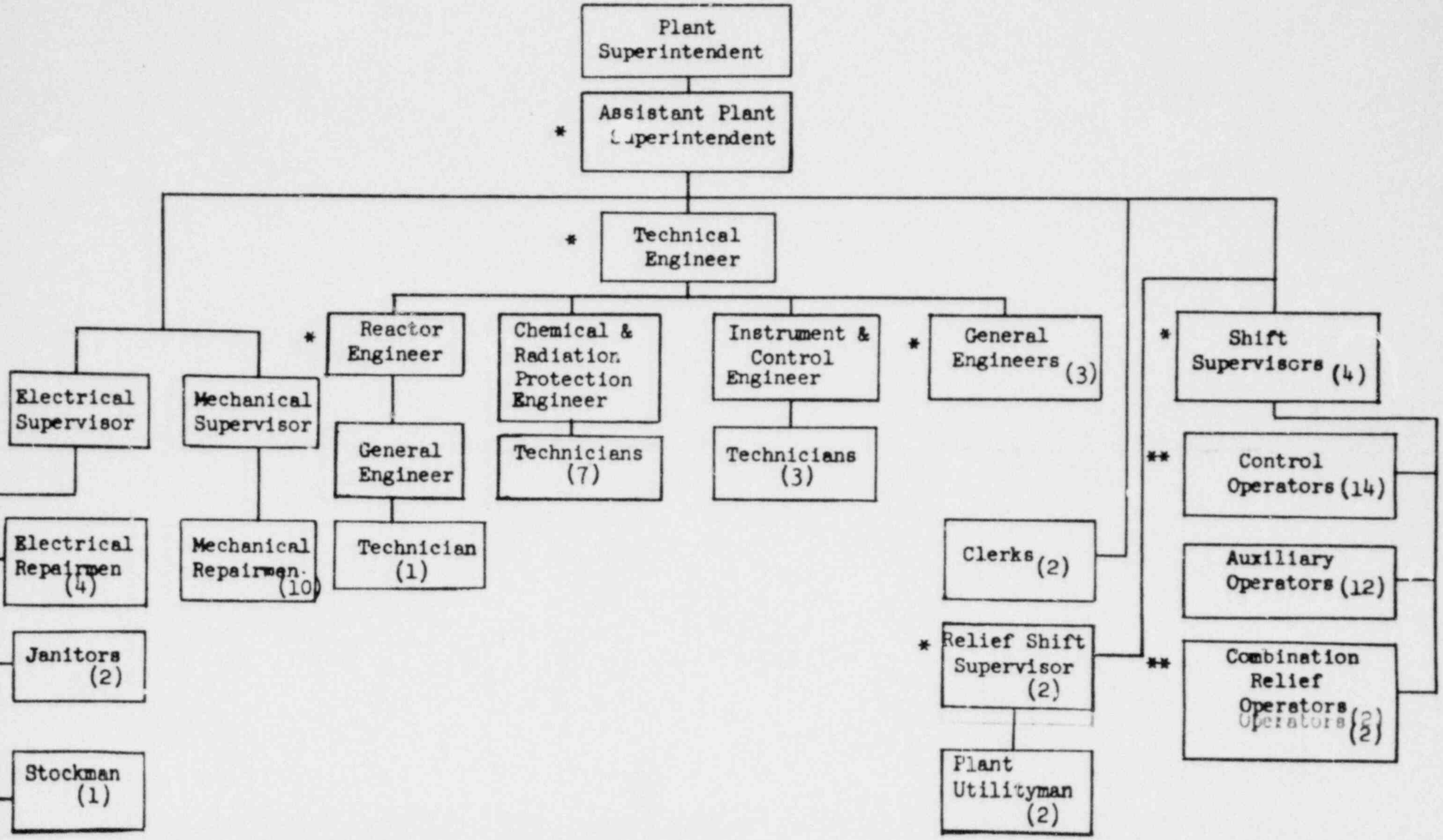
POPULATION DISTRIBUTION
0-50 MILES

FIGURE # 6

CONSUMERS PO[illegible] COMPANY

MIDLAND PLANT

Organization

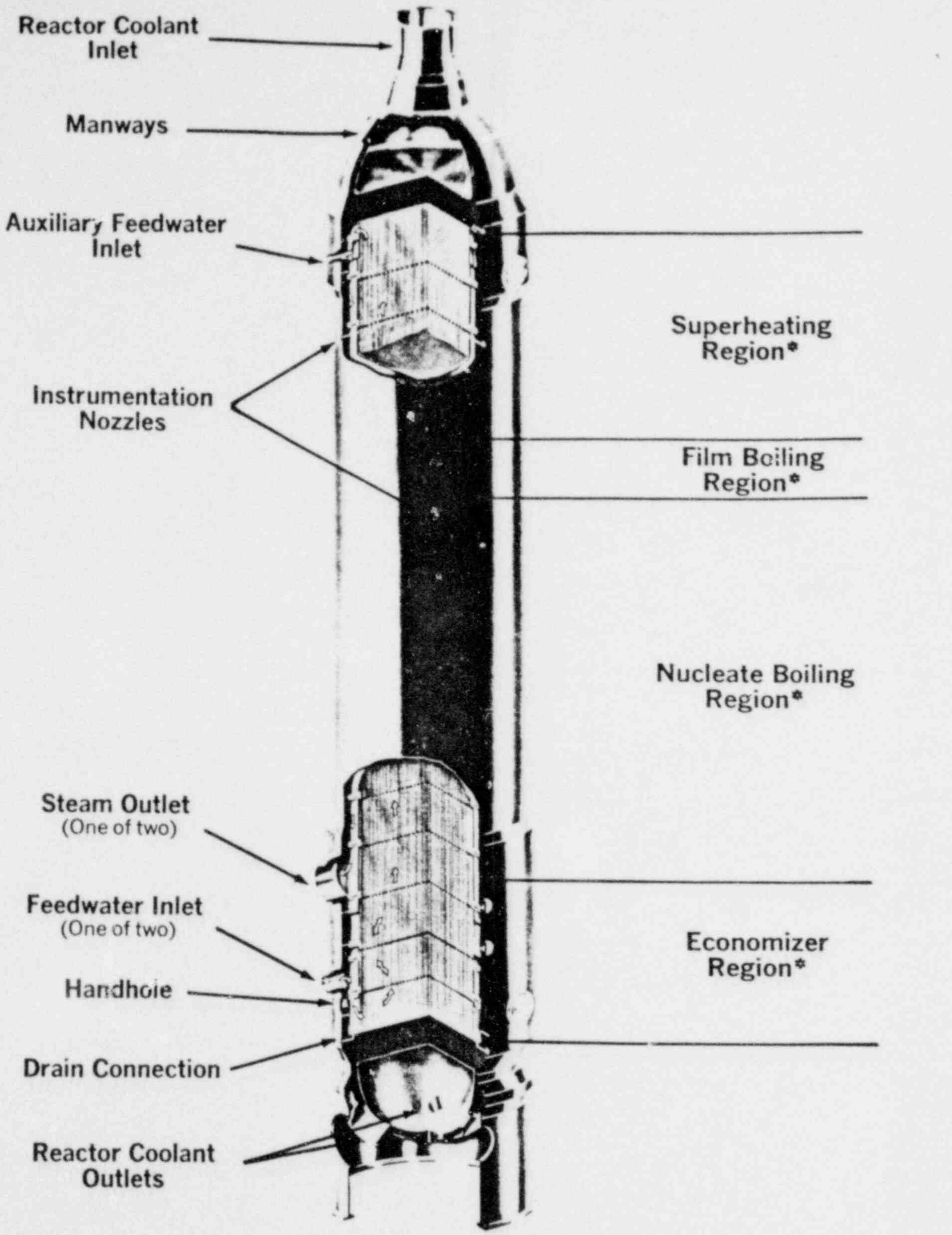


* Pre-critical AEC License

** Post-critical AEC License

Total Plant Personnel (78)

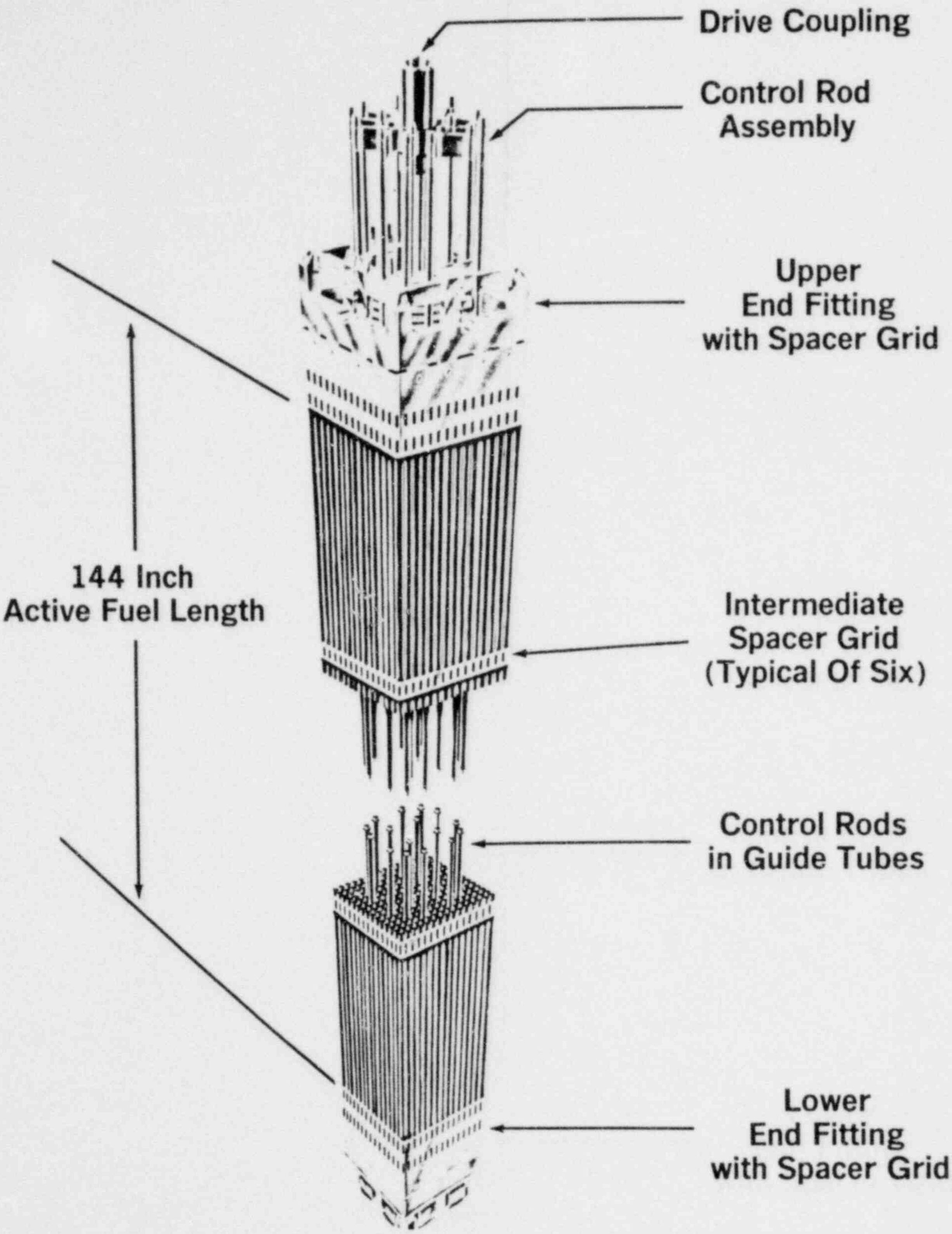
FIGURE #7



Once-Through Steam Generator

Babcock & Wilcox

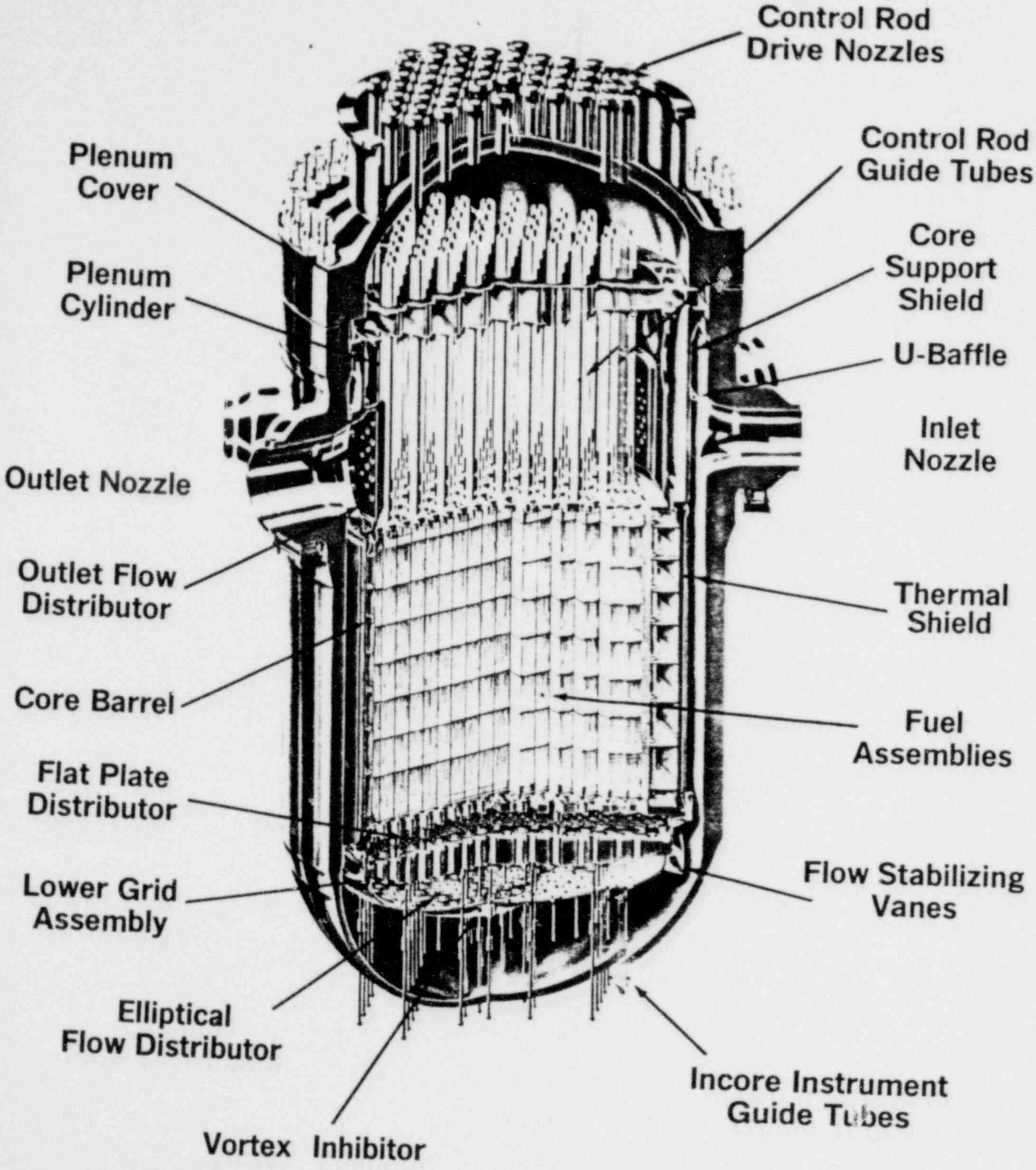
FIGURE 8



Fuel Assembly · Cutaway Showing Partially Inserted Control Rod Assembly

Babcock & Wilcox

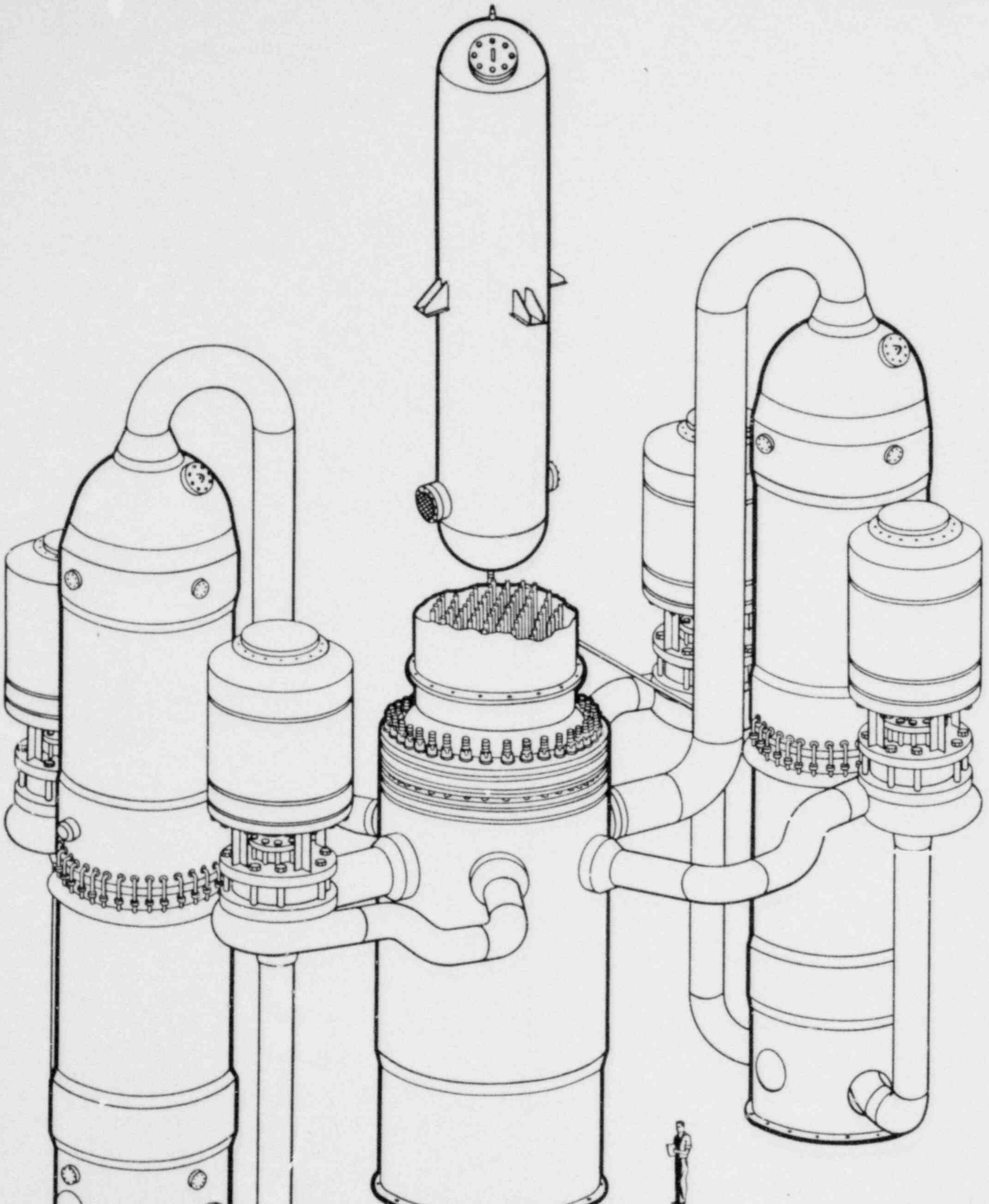
FIGURE 9



Pressurized Water Reactor

Babcock & Wilcox

FIGURE 10



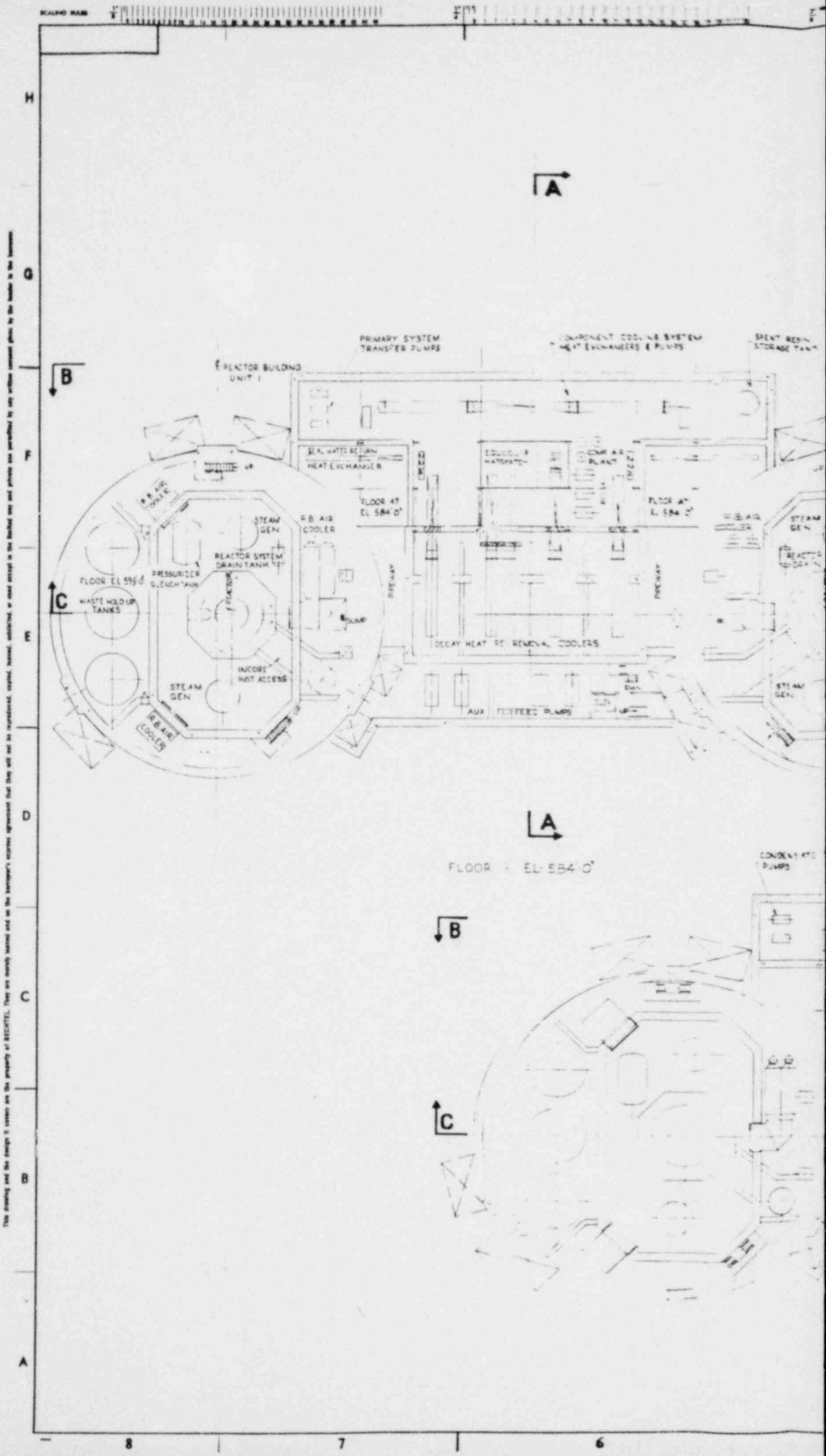
SACRAMENTO MUNICIPAL UTILITY DISTRICT
RANCHO SECO—UNIT NO. 1

CONSUMERS POWER COMPANY
MIDLAND NUCLEAR POWER PLANT—UNITS NO. 1 & 2

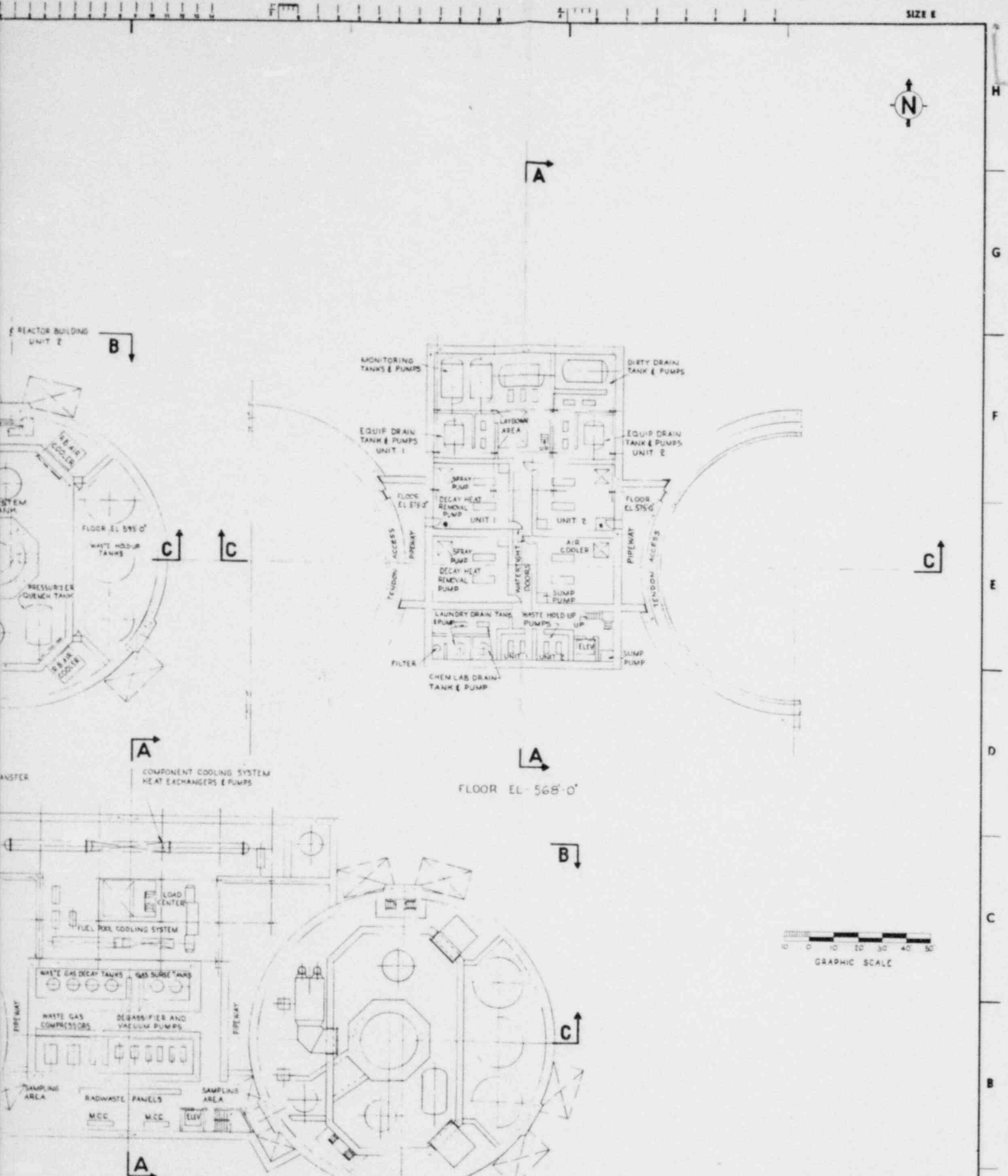
BABCOCK & WILCOX NUCLEAR STEAM SYSTEMS

NOMINAL RATING, MWe	820	STEAM OUTLET PRESSURE, PSIG	910
CAPACITY, LB STEAM PER HOUR	10,600,000	STEAM OUTLET TEMPERATURE, F	570

FIGURE 11



H
G
F
E
D
C
B
A
8
7
6
A
B
C
PRIMARY SYSTEM TRANSFER PUMPS
REACTOR BUILDING UNIT 1
SPENT RESIN STORAGE TANK
SEAL WATER RETURN HEAT EXCHANGER
FLOOR AT EL 584'-0"
COMPR AIR PLANT
R.B. AIR COOLER
STEAM GEN
REACTOR SYSTEM DRAIN TANK
PRESSURIZER QUENCH TANK
WASTE HOLD-UP TANKS
PIPEWAY
DECAY HEAT REMOVAL COOLERS
INCORE INST ACCESS
AUX FEEDWATER PUMPS
PUMP
FLOOR 1 EL 584'-0"
CONDENSATE PUMPS

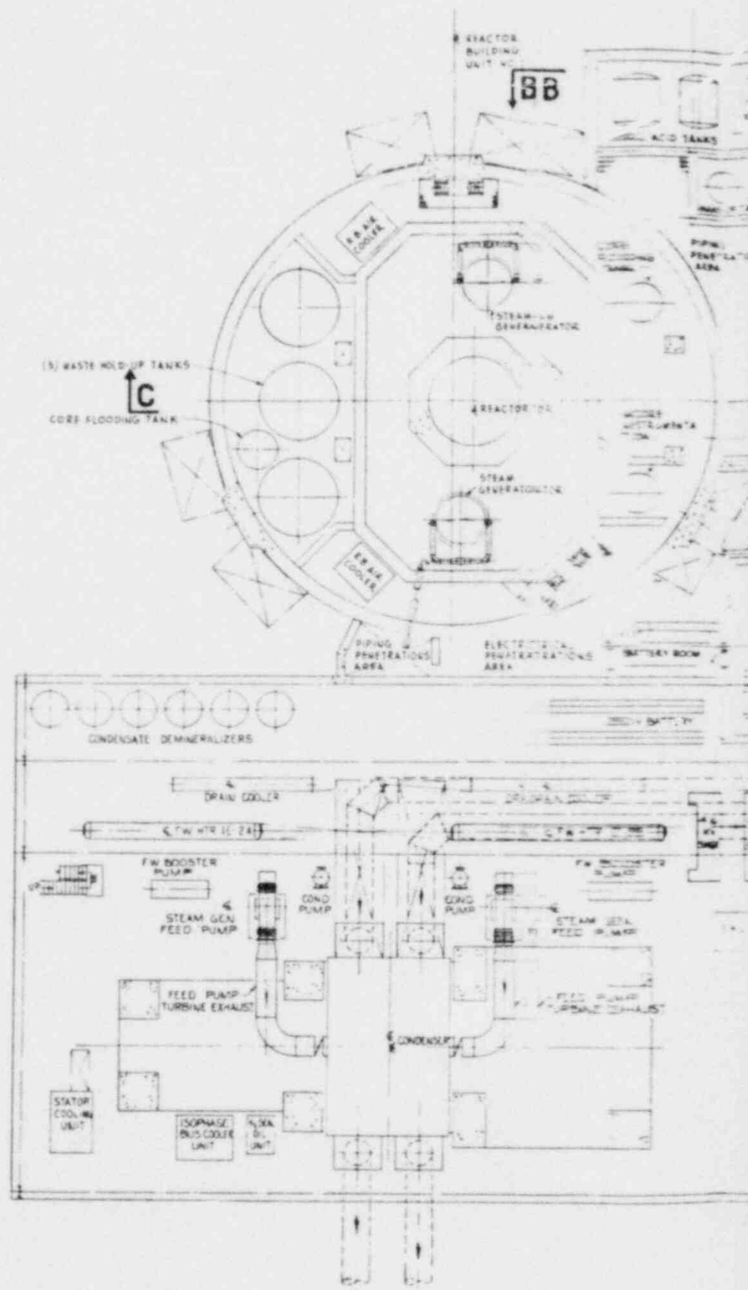


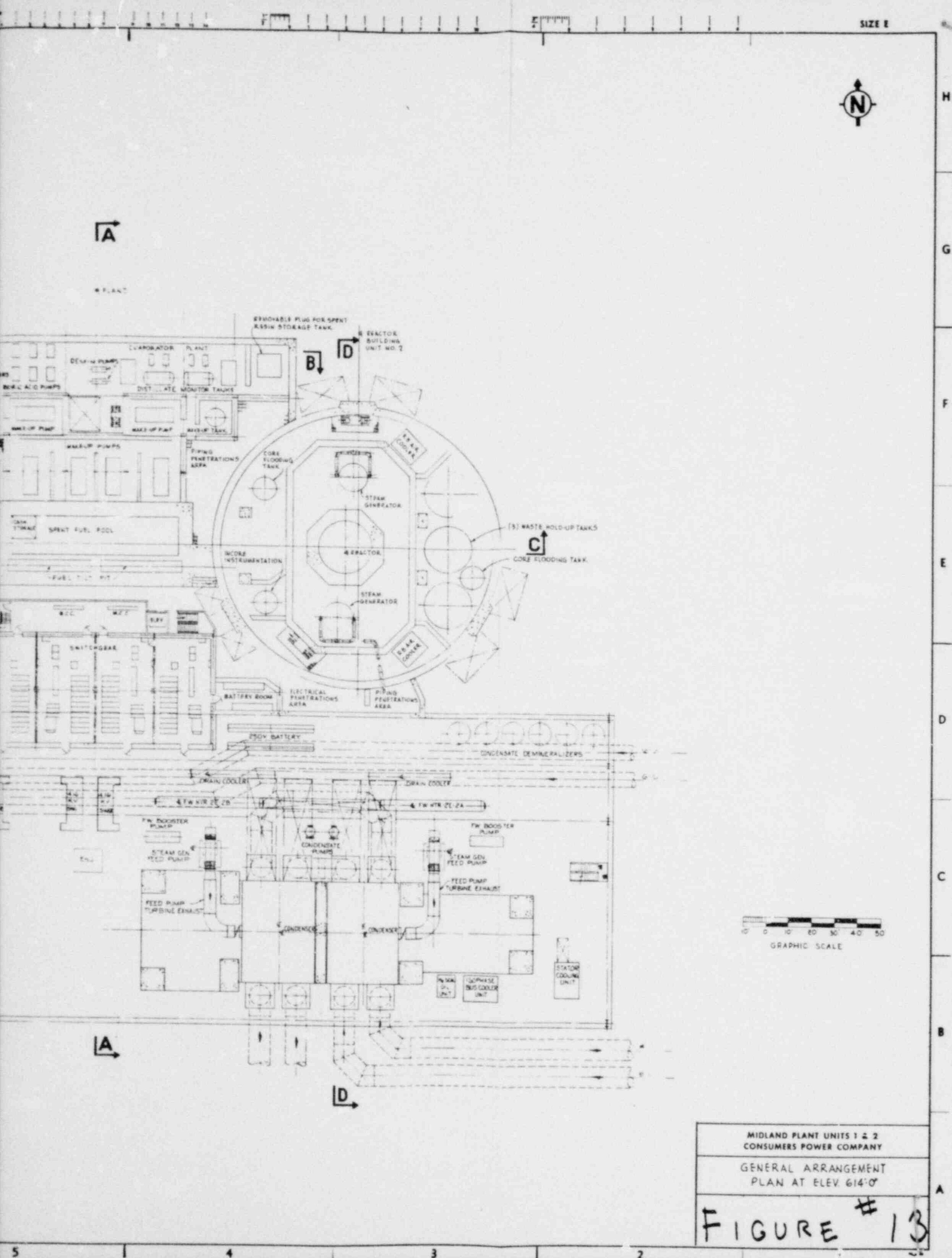
MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

GENERAL ARRANGEMENT
PLANS AT ELEVS 568'0" 584'0" & 599'0"

FIGURE #12

SCALING RULE

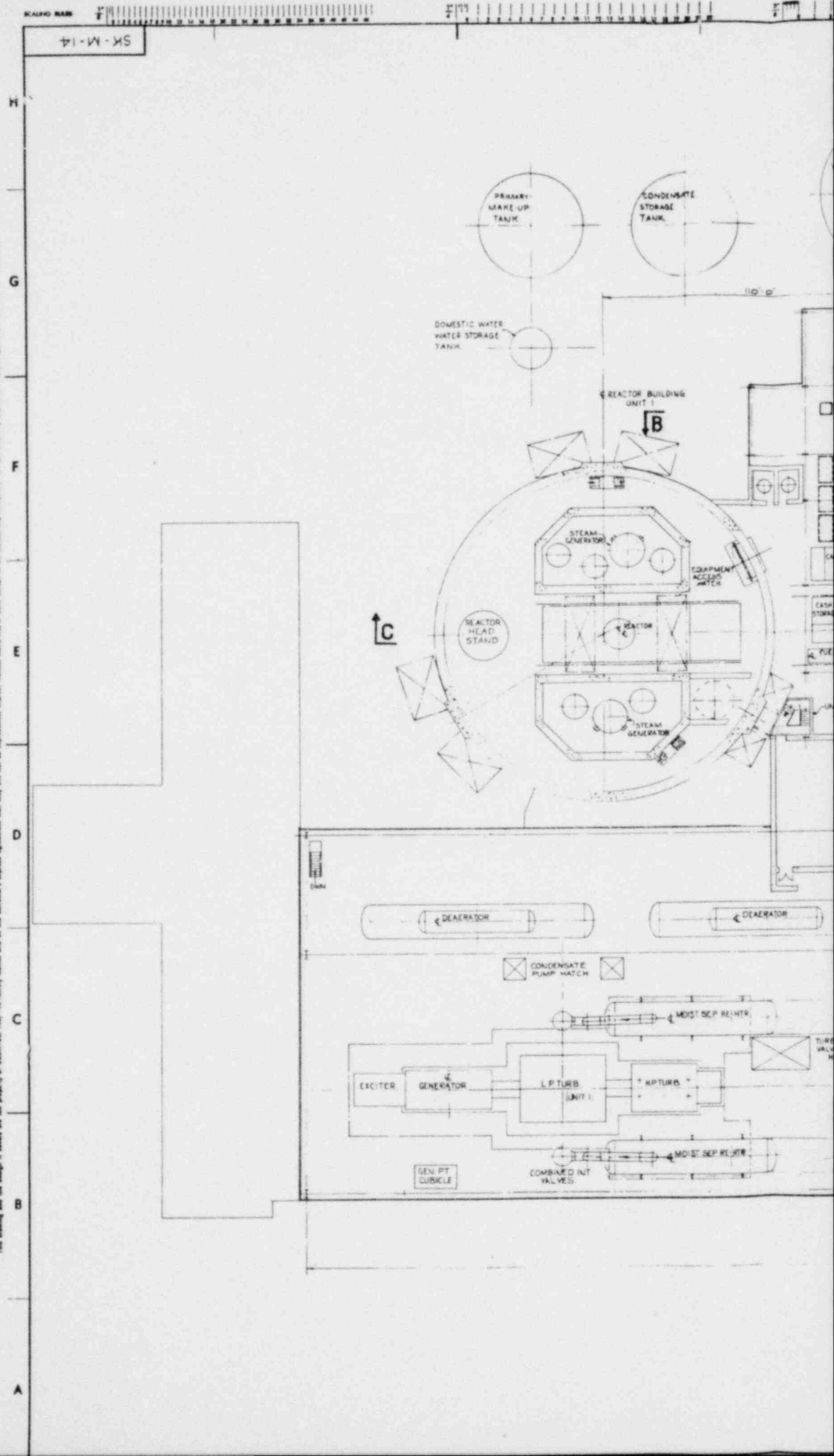


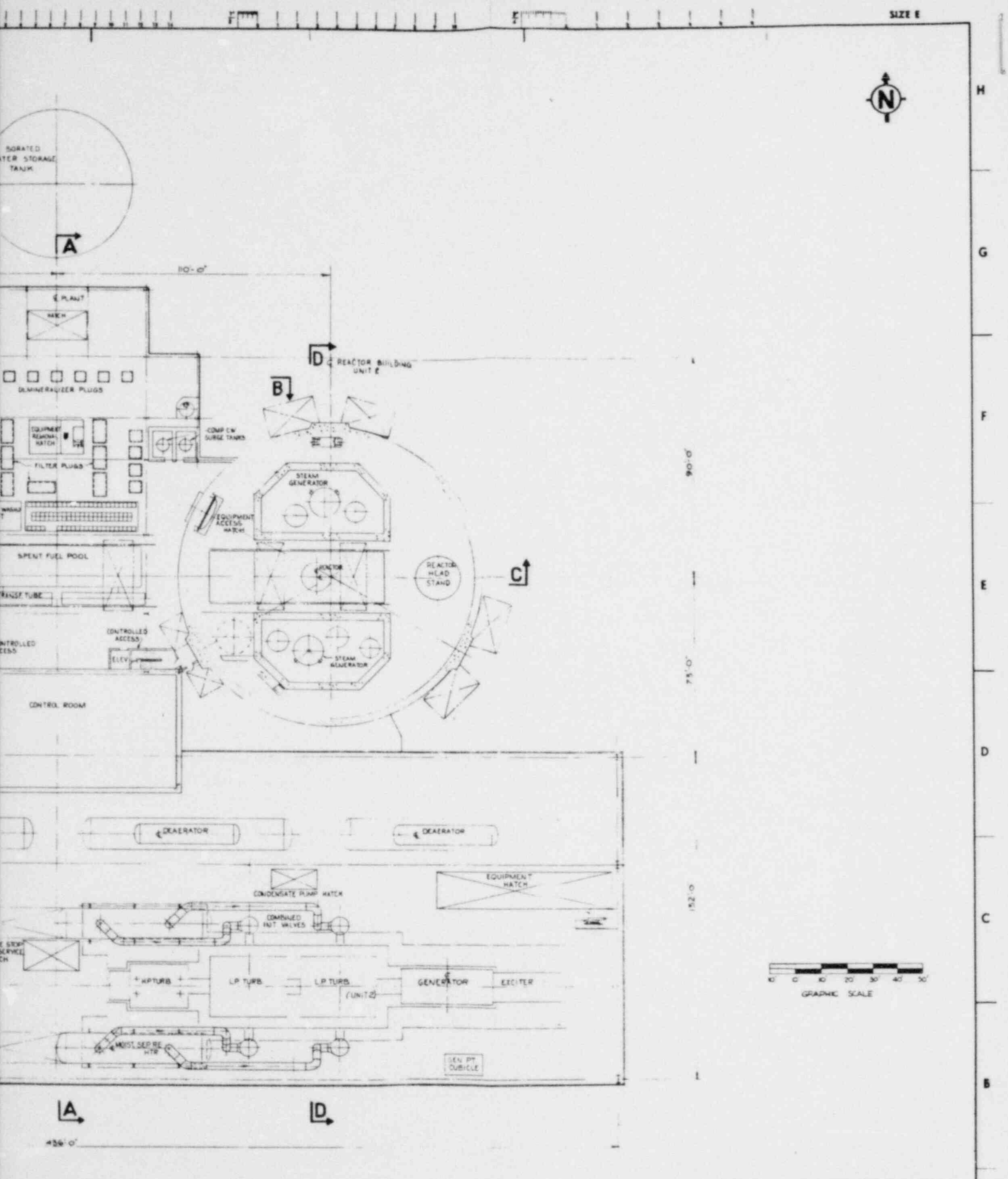


MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

GENERAL ARRANGEMENT
PLAN AT ELEV. 614'-0"

FIGURE #13

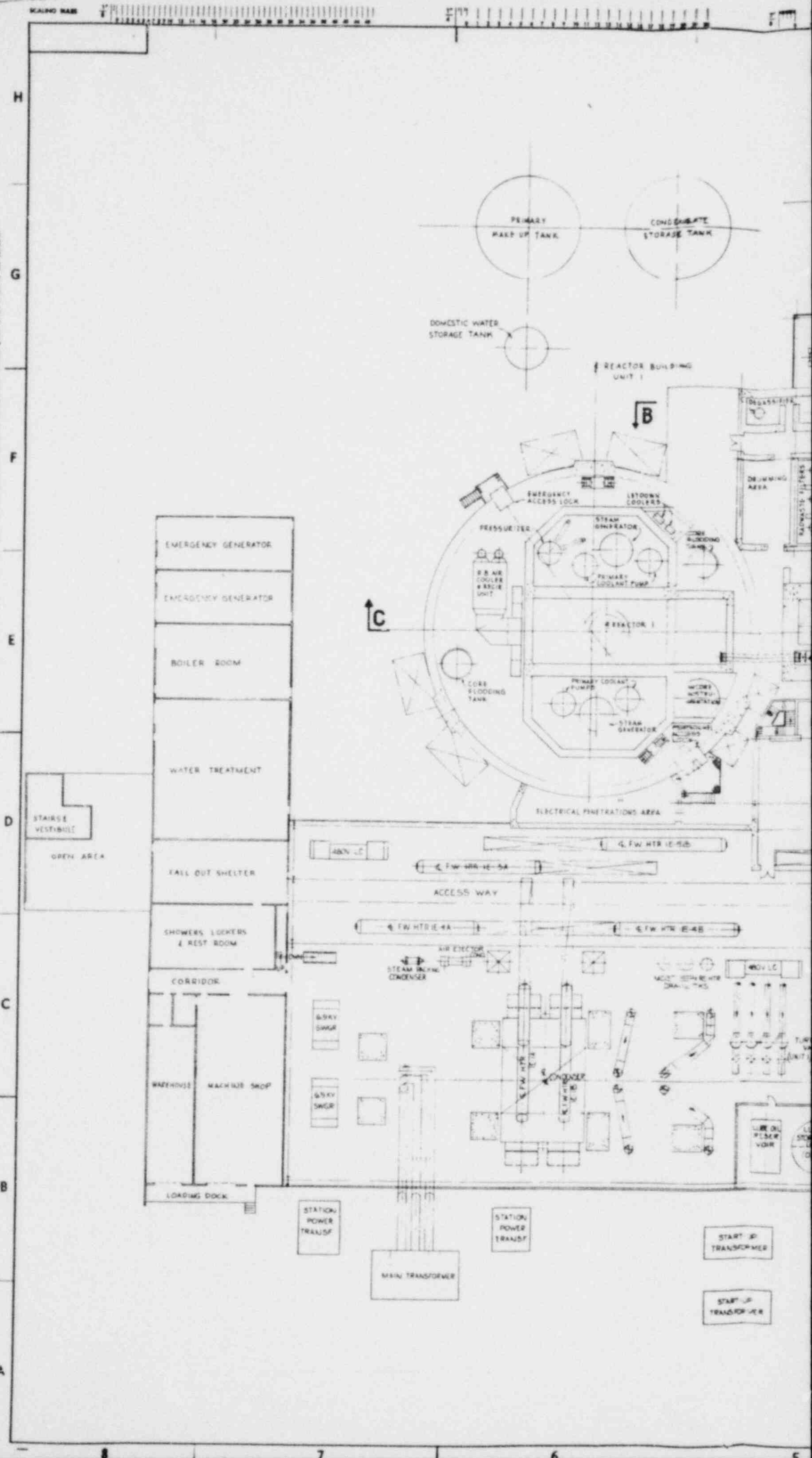

SK-M-14
PRIMARY MAKE-UP TANK
CONDENSATE STORAGE TANK
DOMESTIC WATER WATER STORAGE TANK
REACTOR BUILDING UNIT I
B
STEAM GENERATOR
EQUIPMENT ACCESS HATCH
REACTOR HEAD STAND
REACTOR
C
STEAM GENERATOR
DEAERATOR
DEAERATOR
CONDENSATE PUMP HATCH
MOIST SEP REHTR
EXCITER
GENERATOR
L.P. TURB
(UNIT I)
HP TURB
MOIST SEP REHTR
COMBINED INT VALVES
GEN PT CUBICLE
H
G
F
E
D
C
B
A



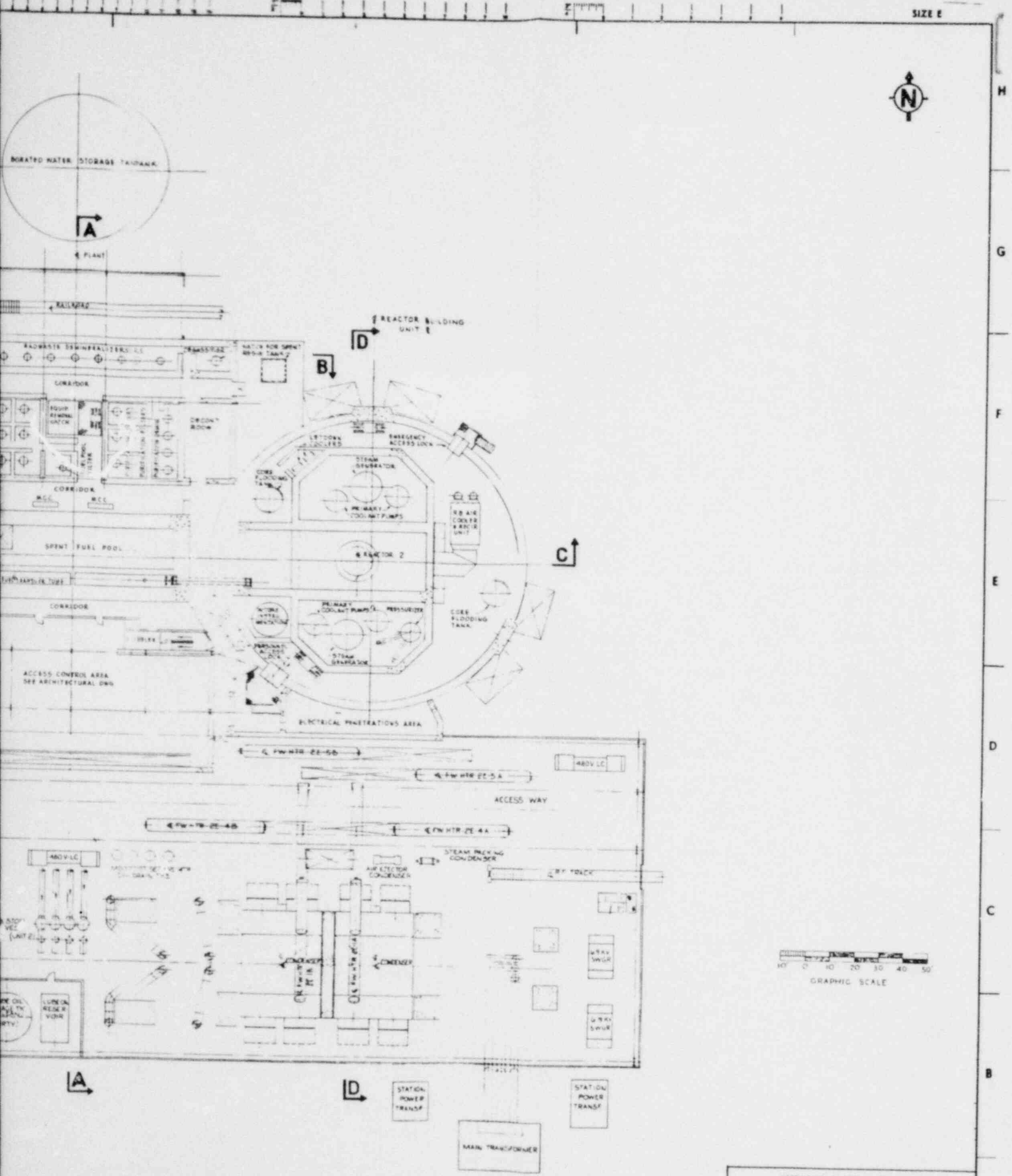
MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

GENERAL ARRANGEMENT
PLAN AT ELEV. 659'-0"

FIGURE #15



SCALING BAR
H
G
F
E
D
C
B
A
8
7
6
5
PRIMARY MAKE UP TANK
CONDENSATE STORAGE TANK
DOMESTIC WATER STORAGE TANK
℄ REACTOR BUILDING UNIT 1
B
C
EMERGENCY ACCESS LOCK
LETDOWN COOLERS
PRESSURIZER
STEAM GENERATOR
PRIMARY COOLANT PUMP
R.B. AIR COOLER & RECIR UNIT
℄ REACTOR 1
CORE FLOODING TANK
PRIMARY COOLANT PUMPS
STEAM GENERATOR
ELECTRICAL PENETRATIONS AREA
DRUMMING AREA
EMERGENCY GENERATOR
EMERGENCY GENERATOR
BOILER ROOM
WATER TREATMENT
STAIRS & VESTIBULE
OPEN AREA
FALL OUT SHELTER
SHOWERS LOCKERS & REST ROOM
CORRIDOR
WAREHOUSE
MACHINE SHOP
LOADING DOCK
480V LC
℄ FW HTR 1E-5B
℄ FW HTR 1E-5A
ACCESS WAY
℄ FW HTR 1E-4A
℄ FW HTR 1E-4B
AIR EJECTOR
STEAM PACKING CONDENSER
480V LC
6.9KV SWGR
6.9KV SWGR
CONDENSER
STATION POWER TRANSF
STATION POWER TRANSF
MAIN TRANSFORMER
START UP TRANSFORMER
START UP TRANSFORMER



MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

GENERAL ARRANGEMENT
PLAN AT ELEV 634' 6"

FIGURE # 14

APPENDIX C

RESEARCH AND DEVELOPMENT PROGRAMS OF INTEREST TO ACRS FIRST IDENTIFIED IN EARLIER CASES

The nuclear steam supply system for the Midland Plant is similar in concept to several projects already in operation, under construction or recently licensed by the Atomic Energy Commission. The preliminary design is based on technical data which has been developed in the nuclear industry and on data developed by B&W which is specifically related to the Midland Plant nuclear design.

Most of the work reported in this section consists of proof-testing of engineered designs, confirmatory tests to confirm analytically predicted conditions, or analytical studies to evaluate design or accident conditions.

The following summarizes the status of the research and development items listed in the PSAR:[1]

1. <u>Once-Through Steam Generator Tests</u>

   The design of the once-through steam generator is based on experimental work on boiling heat transfer and data obtained by B&W in full-length model tests of the unit. The testing of a prototype unit by B&W has been completed. It included performance, mechanical, vibration and blowdown tests, and control system development. The results have confirmed the analytical predictions of performance, and sufficient data on the performance and structural design has been obtained from operation of the test models to finalize the design of the steam generators and to confirm the analytical model developed for steam generator depressurization. The results of the tests are reported in B&W Topical Reports[2,3].

2. Control Rod Drive Line Test

The design of the control rod drive mechanisms is based on a principle which has been used in operating reactors and which has been extensively tested by B&W. Test programs have included full-scale prototype testing under no-flow conditions, full-scale prototype testing at operating conditions, including flow, and components testing. Proof-testing of a prototype mechanism was carried out for a full-life cycle of strokes and trips at optimum and 100 percent misalignment conditions, and major design parameters were confirmed. Data from these test programs confirmed design requirements indicating that rod drop time requirements were met, that excessive wear of components did not occur and that corrosion was not significant. These test data have been reported in B&W Topical reports[4,5].

3. Self-Powered Detector Tests

The testing to demonstrate the performance and longevity of the self-powered detectors in the B&W test reactor and in the Big Rock Point Nuclear Power Plant has been completed. The tests have demonstrated that the detectors perform according to specifications and are capable of measuring neutron flux locally in a PWR environment over a period of several years with a relative accuracy of ±5 percent. At the present time, the detectors have accumulated operational experience equivalent to approximately six years of full power operation in the Midland Plant reactors. The test results are reported in a B&W Topical Report[6].

4. Thermal and Hydraulic Programs

Core thermal performance was evaluated using the W-3 correlation for predicting departure from nucleate boiling. This correlation is available in the literature and has been used and found acceptable in establishing thermal design limits for other large PWR. With the use of this correlation, only the vessel model flow tests were necessary to substantiate operation of the plant within acceptable thermal limits. These flow tests have been completed and have demonstrated acceptable flow distribution for the rated power level. They are reported in a B&W Topical Report[7].

Other thermal and hydraulic work being done by B&W is directed towards improvement in future core designs.

5. Blowdown Forces on Internals

The loads on the reactor and internals following a LOCA and the resultant stresses and deflections in the reactor internals have been analyzed for a skirt supported vessel at another site, and the results are reported in two B&W Topical reports[8,9]. Portions of these analyses will be repeated for the Midland Plant vessels and site seismic characteristics and reported to the AEC staff.

6. Fuel Rod Clad Failure

A B&W program has been conducted to investigate loss-of-coolant accident fuel-clad failure mechanisms in order to insure that none will interfere with the ability of the emergency core cooling systems to accomplish their objectives. The program involved testing and analytical phases. Parametric tests to investigate possible mechanisms of cladding failure including eutectic formation, cladding embrittlement, and cladding swelling and perforation have been carried out. Results indicate that the emergency core cooling systems will effectively cool the core, even if substantial fuel rod swelling occurs. This work is described in a B&W Topical Report(10).

7. Xenon Oscillations

The possibility of the occurrence of xenon oscillations throughout the core life is being evaluated analytically by B&W(11). A modal analysis and one, two and three dimensional calculations have been carried out for a core design similar to the Midland Plant to evaluate axial, azimuthal, and radial oscillations including methods for controlling possible oscillations(12,13,14). Xenon oscillations are primarily an operational problem, not a critical safety problem, because the oscillations would be slow (25-30 hours) and can be controlled by operator action. Confirmatory analyses will be carried out on the Midland Plant core design and will be reported to the AEC staff.

8. Iodine Removal Spray

The design of the iodine removal spray system is based on information obtained from R&D Programs conducted by B&W and others. These programs have demonstrated the ability of the chemical sprays to effectively remove and retain iodine and the stability and chemical compatibility of the spray solution. The results of these programs are reported in B&W Topical Reports[15,16].

9. Internals Vent Valves

A test program, including hydrostatic, closing at zero pressure, pressure differential verification, functional handling, vibration and prototype testing, has been completed and the test program demonstrated that the vent valve design will perform adequately during both normal operating and accident conditions. The results of the tests on the full-sized valves and on the prototype valves are reported in B&W Topical Reports[7,17].

References

1. PSAR, Volume I, Section 1.5; PSAR Amendment No 5, Item 1.1.
2. BAW-10002, "Once-Through Steam Generator Research and Development Report" (PROPRIETARY).
3. BAW-10002, Supplement 1, "Once-Through Steam Generator Research and Development Report" (PROPRIETARY).
4. BAW-10007, "Control Rod Drive System Test Program."

5. BAW-10007, Supplement 1, "Control Rod Drive System Test Program."

6. BAW-10001, "In-Core Instrumentation Test Program."

7. BAW-10012, "Reactor Vessel Model Flow Tests" (PROPRIETARY).

8. BAW-10008, Part 1, Rev 1, "Reactor Internals Stress and Deflection Due to Loss-of-Coolant Accident and Maximum Hypothetical Earthquake."

9. BAW-10008, Part 2, Rev 1, "Fuel Assembly Stress and Deflection Analysis Due to Loss-of-Coolant Accident and Seismic Excitation" (PROPRIETARY).

10. BAW-10009, "Effect of Fuel Rod Failure on Emergency Core Cooling" (PROPRIETARY).

11. PSAR, Volume 1, Section 1.5.1 and Section 3.2.2.2.3 and Appendix 3A.

12. BAW-10010, Part 1, "Stability Margin for Xenon Oscillations - Modal Analysis."

13. BAW-10010, Part 2, "Stability Margin for Xenon Oscillations - One-Dimensional Digital Analysis."

14. BAW-10010, Part 3, "Stability Margin for Xenon Oscillations - Two- and Three-Dimensional Digital Analysis."

15. BAW-10017, Rev 1, "Research and Development Report in the Stability and Compatibility of Sodium Thiosulfate Spray Solutions - R&E Report" (PROPRIETARY).

16. BAW-10022, "Effectiveness of Sodium Thiosulfate Sprays for Iodine Removal" (PROPRIETARY).

17. BAW-10005, "Internals Vent Valve Evaluation" (PROPRIETARY).