FINAL REPORT
MIDLAND POWER PLANT
COOLING POND OPERATION STUDY

FOR

CONSUMERS POWER COMPANY

PREPARED BY

DR. C. P. LIOU, ENGINEERING SPECIALIST
DR. C. N. PAPADAKIS, ASST. CHIEF ENGINEER

HYDRAULICS AND HYDROLOGY GROUP
GEOTECHNICAL SERVICES - ANN ARBOR

BECHTEL ASSOCIATES PROFESSIONAL CORPORATION

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TABLE OF CONTENTS

Table of Contents (continued)

TABLE OF FIGURES

Table of Figures (continued)

TABLES

SB178165

1. SUMMARY

The Midland Plant cooling pond operation was simulated using a model which incorporated a makeup-blowdown system to control the concentration of total dissolved solids and the water surface elevation of the cooling pond. Reasonable assumptions regarding the timing and quantity of makeup withdrawal from the Tittabawassee River and blowdown discharge into the river were used. A physical model study was conducted at Alden Research Laboratory to determine permissible blowdown flowrates so that the applicable Water Quality Standards of the Michigan Water Resources Commission would be satisfied by both the discharges from Dow Chemical Company and from the cooling pond of the Midland Power Plant.

The cooling pond operation was simulated on a daily basis for 82 years. The following conclusions can be made:

a. It is feasible to control the concentration of total dissolved solids and the depth of the cooling pond within design limits through the makeup-blowdown system.

b. The blowdown discharges into the Tittabawassee River can comply with the Water Quality Standards of the Michigan Water Resources Commission.

c. On a long term basis, cooling pond blowdown and the resulting thermal plumes in the Tittabawassee River may occur only 30% of the time.

d. In this study, the Dow Chemical Company's discharge had priority over the Midland Plant blowdown discharge. As a result, the total

dissolved solids in Dow's discharge severly limited the occurrence of the cooling pond blowdown discharge.

e. The operation of the makeup-blowdown system is limited by its ability to blowdown due to thermal plume considerations. There is sufficient water for pond makeup in the Tittabawassee River, and there is no significant effect on the river flowrates because of makeup withdrawal.

SB178167

2. INTRODUCTION

2.1 Midland Plant and Its Cooling Pond

The Midland Power Plant is near the Tittabawassee River at the southern limit of the city of Midland, Michigan. It utilizes two Babcock and Wilcox pressurized water reactors to generate approximately 1300 MWe of electricity and 4 million pounds per hour of steam. A cooling pond is used to transfer the waste heat removed by the condenser cooling water system to the atmosphere. The maximum heat rejection rate from the condensers to the cooling pond is 9.05×10^9 Btu/hr corresponding to the Unit 1 back end limited and Unit 2 valves wide open operation condition.

The heat rejected to the pond is dissipated by evaporation, back radiation and conduction processes into the atmosphere. To adequately dissipate the waste heat and to provide sufficient storage of water for plant cooling during droughts, the pond is designed with a surface area of 880 acres at the design pond water surface elevation of 627 ft. and a surface area of 860 acres at the minimum pond water surface elevation of 618 ft. The pond volumes are about 12,600 acre-ft. and 4,800 acre-ft. for the maximum and minimum water surface elevations respectively. The average full pond depth is 14.3 ft. The pond has a baffle dike which prevents direct exchange of water between the hot and the cold side of the pond, and promotes the effective use of the entire pond surface area. The Tittabawassee River and the cooling pond configuration are shown in Figure 1.

SB178168

Due to evaporative loss of the pond water during the heat dissipation process, total dissolved solids (TDS) accumulate in the pond and thus their concentration must be controlled. A cooling pond makeup-blowdown system is utilized for this purpose. A portion of the pond water from the cold end of the pond is discharged by gravity into the Tittabawassee River, and fresh river water is pumped into the pond to makeup for water losses due to evaporation and blowdown. Consequently, the pond water depth and TDS concentration can be regulated to a certain degree by the makeup-blowdown system. A sketch of the system is shown in Figure 2. Three makeup pumps with a combined rated capacity of approximately 210 cfs are used to supply makeup water to the cooling pond. Blowdown is discharged by gravity to the river via three 2.5 ft. diameter pipes. The design blowdown flow range is between 5 cfs and 220 cfs. Details of the physical makeup-blowdown system are described in Reference 1.

The mechanical equipment of the Plant's circulating water system is designed for a nominal average TDS concentration of 1206 ppm and a nominal maximum of 1832 ppm (Reference 2). The makeup-blowdown system should be operated in such a way that the pond average TDS concentration meets the requirement of the mechanical equipment.

2.2 The Tittabawassee River

The Tittabawassee River basin is near the center of Michigan's lower peninsula. The river flows generally southward to the village of Sanford. After Sanford, it meanders to the southeast and flows into the Saginaw River at the City of Saginaw, about 20 miles downstream from Midland. Twenty-two miles downstream from its confluence with the Tittabawassee, the Saginaw River empties into Saginaw Bay, an arm of Lake Huron. The Tittabawassee River drainage area above Midland encompasses 2,400 square miles.

There are three hydroelectric dams along the Tittabawassee River upstream from Midland. The one closest to the plant (the Sanford Dam) is located at Sanford about 10 miles upstream from Midland. The dam is owned and operated by Wolverine Power Company which generates electricity for part of the day on weekdays. Tittabawassee River flow at Midland varies according to the Sanford Dam operation.

Dow Chemical Company's industrial complex lies north of the Midland Power Plant across the Tittabawassee River. Dow diverts river water for industrial use at the Dow Dam, located about 6700 ft. upstream from the river intake structure of the Midland Power Plant. On the right bank of the river (looking downstream) and 2000 ft. downstream from the Dow Dam there is a gaging station maintained by the U. S. Geological Survey (USGS). Examination of the record of rating curves prepared by USGS indicates that the river bed is movable at the vicinity of the plant. The USGS checks and updates its rating curve every five weeks. Daily average river flow data at the gaging station is available from March 1936 to present. The daily flow duration curve at the USGS Midland gaging station on the Tittabawassee is shown in Figure 3. The average river flow is about 1680 cfs.

2.3 Applicable Water Quality Standards

Discharge of cooling pond blowdown into the Tittabawassee River has two physical effects: creation of a thermal plume, and addition of TDS to the river. To protect the water quality of the river, the following rules of the Michigan Water Resources Commission (MWRC) (Reference 3) shall be satisfied:

a. Heat load to the river shall not warm the receiving water at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures:

Month:	J	F	M	A	M	J	J	A	S	O	N	D
°F:	41	40	50	63	76	84	85	85	79	68	55	43

b. Heat load to the river shall not warm the receiving water at the edge of the mixing zone more than 5°F.

c. The size of the mixing zone is limited such that it does not contain more than 25% of the cross-sectional area or volume of flow of the river at any river transect, or both.

d. The controllable addition of TDS to the river shall not increase the river TDS concentration beyond 500 ppm as a monthly average nor more than 750 ppm at any time.

Dow Chemical Company discharges its tertiary pond effluent into the Tittabawassee River about 300 ft. upstream from the location of the cooling pond blowdown discharge. Both discharges are at the south bank of the river as shown in Figure 2. Dow's effluent adds heat and TDS to the river. The rules of the Michigan Water Resources Commission apply to the combined effect of both the Dow and Midland Plant discharges in this study. During plant operation, average river TDS concentration will be measured at the Freeland Bridge located approximately 14 miles downstream from the cooling pond blowdown discharge structure.

2.4 Scope and Purpose of the Study

The objective of the study is to demonstrate that the cooling pond depth and TDS concentration can be satisfactorily controlled by the makeup-blowdown system without violating the thermal and TDS limits in the Tittabawassee River. Anticipated variations in pond depth and TDS concentration are simulated, on a daily basis for 82 years, by employing a set of reasonable operational assumptions for the system. The results of this simulation provide the basis for preparing several sections of the Midland Plant Environmental Report and for the NPDES Application for Permit to Discharge Wastewater.

3. PHYSICAL AND OPERATIONAL ASSUMPTIONS

3.1 Physical Assumptions

Simulation of the daily operation and the variations in pond depth and TDS concentration was based on the following physical assumptions:

a. Total dissolved solids in the cooling pond come only from the Tittabawassee River. TDS input from plant operation, circulating water acid and hypochlorite addition and the possible discharge of condensate demineralizer regeneration waste, is not significant and is not considered.

b. Cooling pond volume gain by precipitation and runoff is neglected. This is a conservative assumption since an annual average precipitation of 30 inches (Reference 4) over the pond surface of 880 acres equals 3 cfs, or approximately 13% of annual average evaporation rate for the entire heated pond.

c. A constant seepage loss of 0.5 cfs is assumed for each day (Reference 1). No credit is taken for TDS loss from the cooling pond via seepage.

d. Pond TDS are uniformly distributed throughout the pond volume.

e. The effluent of Dow Chemical Company's tertiary pond is assumed to have a flowrate of 67 cfs with an excess temperature of 5°F and a TDS concentration of 2500 ppm.

f. Average daily Tittabawassee River flows from water years 1937 to 1977 are used.

g. The pond is assumed to be full and have a TDS concentration of 500 ppm at the beginning of the simulation.

3.2 Operational Assumptions

The operation of the cooling pond, i.e., timing and quantity of makeup and blowdown flows, was governed by the following assumptions:

a. The annual refueling period for each unit is assumed to be one month. Refueling occurs in September for Unit 1 and in April for Unit 2. The heat load to the cooling pond is 3,370 x 10^6 Btu/hr for April; 5,680 x 10^6 Btu/hr for September and 9,050 x 10^6 Btu/hr for the remaining months of the year. More details on the heat loads can be found in Reference 5.

b. The constraints on makeup flowrates are listed in Reference 1 and are graphically presented in Figure 4 as a function of river flows. The maximum makeup flow utilized in the pond operation simulation is 270 cfs corresponding to the makeup pumps runout conditions.

c. Blowdown flowrates are not to exceed a set of maximum allowable values derived from considerations of thermal constraints in the Tittabawassee River.

d. Blowdown discharge shall not cause downstream river average TDS concentration to exceed 500 ppm measured at the Freeland Bridge.

e. The maximum blowdown flowrate is limited to 220 cfs because of hydraulic characteristics of the gravity fed blowdown scheme. The minimum blowdown flowrate is 5 cfs due to difficulty in throttling for flows below 5 cfs.

f. The pond water surface elevation imposes the following limits on the makeup and blowdown flowrates:

1. When pond level is above 627 ft., no makeup is permitted and blowdown may be discharged at its maximum allowable flowrate.

2. When pond level is below 626.5 ft., no blowdown is permitted and makeup withdrawal may be made at its maximum allowable flowrate.

3. When pond level is between 627 ft. and 626.75 ft., both makeup withdrawal and blowdown discharge may be made at their maximum allowable flowrates.

4. When pond level is between 626.75 ft and 626.5 ft., makeup flowrate may be set at its maximum allowable value and the blowdown flowrate is limited so that the pond level is not lowered because of blowdown discharge.

g. Dow Chemical Company's effluent discharge into the Tittabawassee River is given priority over the Midland Plant cooling pond blowdown discharge. When the downstream average river TDS concentration equals or exceeds 500 ppm due to Dow effluent, cooling pond blowdown discharge is terminated.

h. Pond blowdown discharge is terminated when daily average natural river temperatures are within 5°F of the monthly maximum temperatures listed in Section 2.3-a.

4. DATA

The data used in the study include river flows, natural river temperatures, natural river TDS concentrations, cooling pond evaporation rates, blowdown temperatures, and maximum allowable blowdown flowrates. The sources of the data are discussed below.

4.1 River Flows

The U. S. Geological Survey (USGS) maintains a gaging station at Midland on the Tittabawassee River. The gaging station is located 4700 ft. upstream from the Midland Plant river intake structure. The Bullock Creek drains into the Tittabawassee River between the gaging station and the river intake structure, but its flow is insignificant compared with that of the Tittabawassee River. Daily average river flows published by the USGS from water years 1937 to 1977 (Reference 6) were used in the cooling pond operation study (A water year starts October 1 and ends September 30, i.e., water year 1976 extends from October 1, 1975 to September 30, 1976).

4.2 Natural River Temperatures

Continuous instantaneous measurements of natural river temperature are made by the Dow Chemical Company at the Dow Dam. Daily average natural river temperatures from October 1, 1975 to September 30, 1978 were extracted from the original continuous record and were provided for this study by Dow Chemical Company. These three years of temperature records were used to establish a model for generating long term daily natural river temperatures from available daily dry bulb temperatures recorded at the Bishop Airport of Flint, Michigan, a Class 1 station of the National Weather Service.

Variations in natural river temperature and in dry bulb temperature at the same location can be separated into seasonal and non-seasonal components. Seasonal variations in daily natural river temperature can be established by subjecting the river temperature record to a Fourier analysis. The first few harmonics that account for a large percent of total variance yield daily river temperatures that vary smoothly according to seasonal trend. The non-seasonal variation in daily river temperatures, herein called river temperature residue, is obtained by subtracting the seasonal component from the known daily river temperature. Seasonal daily dry bulb temperature and dry bulb temperature residue can be obtained by the same process.

The river temperature residue on any given day can be correlated to the dry bulb temperature residue for that day and two preceding days by linear multiple regression. Thus river temperature residue can be predicted as a linear combination of dry bulb temperature residues. Natural river temperatures can then be generated by adding the river temperature residues to the seasonal daily river temperatures. This procedure was used successfully to predict Illinois River water temperatures at Havanna for 1968 and 1969 (Reference 7).

Daily average natural river temperatures and dry bulb temperatures for an "average year" were established by averaging the daily temperatures for water years 1976, 1977 and 1978. The model to generate daily river temperatures from dry bulb temperatures was established from the seasonal daily river temperatures and the residues of dry bulb and river water temperatures of the "average year".

Natural river temperatures were generated from March 1, 1949 to September 30, 1978. A comparison of mean and standard deviation of the recorded and calculated natural river temperatures for water years 1976, 1977 and 1978 is shown in Table 1. A day to day comparison of recorded and calculated natural river temperatures for water year 1976 is shown in Figure 5.

Table 1

Characteristics of Natural River Temperature

Year	Observed °F		Calculated °F	
	Mean	Standard Deviation	Mean	Standard Deviation
1976	58.82	15.21	60.43	14.94
1977	61.90	14.67	61.27	14.46
1978	60.60	15.80	60.59	14.95

Flint dry bulb temperatures were used instead of those at Midland because no accurate long term air temperature record at Midland was available, while important meteorological parameters (including dry bulb temperature) were readily available for Flint since January 1, 1949. Furthermore, the applicability of Flint data to Midland has been demonstrated in Reference 8.

Calculated river temperatures for water year 1976 were used repeatedly from water years 1937 to 1948 for which no air temperatures were available.

S3178179

4.3 Natural River TDS Concentration

Daily natural river TDS concentrations were either directly obtained, or estimated from the natural river conductivities contained in the Monthly Operating Report of Dow Chemical Company from October 1975 to September 1977. In the Operating Report, both TDS concentration and conductivity were reported for only 8 to 10 days per month. An average ratio of TDS concentration in ppm to conductivity in micromhos per centimeter was computed from these pairs for each month. For the remaining days where only conductivities were reported, the TDS concentrations were estimated by multiplying the conductivities by the established ratio. The daily natural river TDS concentrations for water years 1976 and 1977 are shown in Figure 6. The 1976 values were used repeatedly in the study. The sensitivity of pond TDS concentration with respect to natural river TDS concentration is discussed in Chapter 6.

4.4 Maximum Allowable Blowdown Flowrates

A physical model testing program has been conducted at the Alden Research Laboratory (ARL) to determine the blowdown flowrate at a given excess temperature that can be discharged into the Tittabawassee River without violating the 25% limits for the thermal mixing zone, and without resulting in a mixing zone more than 1700 ft. long (Reference 9). A fixed bed physical model of a 2000 ft. reach of the Tittabawassee River downstream from the plant makeup intake was used to determine the maximum allowable blowdown flowrate at a given river flow and blowdown excess temperature. This physical model is an approximation of the prototype which is a movable bed alluvial river with unsteady flows.

Both the Dow tertiary pond discharge and the cooling pond blowdown were simulated in the physical model. For each model test, the Dow effluent was set at 65 cfs with an excess temperature of 5°F and a TDS concentration of 3000 ppm, conservatively larger than the 2500 ppm used in the operation study. The negative buoyancy of the Dow plume had no effect on the mixing of blowdown discharge with river water. A matrix of 275 thermocouples, positioned throughout the model, was used to determine the maximum allowable blowdown flowrate for a given blowdown excess temperature and river flow.

It was found that the edge of the thermal plume was not smooth and steady, but somewhat ragged and time varying due to turbulence and eddy shedding caused by the interaction of the river with the Dow discharge and the Midland Plant blowdown. Therefore, for all data provided, the edge of the thermal plume was based on the location of the 5°F excess temperature isotherm as determined by the average temperatures obtained from 25 scans of each of the thermocouples on the physical model over an averaging period of 16 minutes model time (62 minutes prototype time).

The model test results were reported in terms of a set of curves that relate the maximum allowable blowdown flowrates with blowdown excess temperatures over a range of river flows as shown in Figures 26 to 30 of Reference 9.

Due to pressing time schedules, the physical model was not adequately verified against its prototype before starting the final test series.

Some verification tests were conducted after the final test series was completed. These verification tests indicated that the physical model was too smooth for river flows greater than about 1200 cfs. As a result, the average velocity of the river upstream from the blowdown discharge was higher than that of the prototype. This higher average river velocity tends to make thermal plumes narrower. Consequently, the blowdown flowrates for those tests with thermal plume sizes that essentially coincide with the 25% limits described in Section 2.3-c were reduced. The modified curves, representing the maximum blowdown flowrates for river flows (after makeup withdrawal) ranging from 770 cfs to 3450 cfs, are shown in Figure 7.

Because of the limited capacity of the test facilities at the Alden Research Laboratory, the physical model could not accommodate river flows higher than approximately 3800 cfs. Thus, indirect calculation of maximum blowdown flowrates became necessary at higher river flows.

A "theoretical" maximum blowdown at a given excess temperature can be calculated by assuming it mixes fully with a quarter of river flow that contains the discharge from Dow Chemical Company. The assumed temperature profile in the river is "top-hat" shaped with an uniform excess temperature of 5°F over the quarter of river used. Model test results obtained at Alden Research Laboratory indicated that in order for the 5°F excess temperature isotherm to close within the physical model, the "actual" blowdown flowrate at the same excess temperature is less than the theoretical flowrate. The ratio of the blowdown flowrates that ensures the closure of the 5°F isotherm over the theoretical flowrate was related to the velocity of blowdown over a range of river flows according to model test results.

In the daily pond simulation, blowdown excess temperature and river flow were available for computing the ratio of blowdown flowrates. The blowdown velocity, and consequently the blowdown flowrate, could then be calculated. This procedure was used to compute the maximum allowable blowdown flowrate for days when river flow was above 4000 cfs.

4.5 Blowdown Temperatures and Pond Evaporative Water Losses

A transient cooling pond mathematical model was used to estimate daily average blowdown temperatures and pond evaporative water losses. This computation was carried out separately from the time history of the pond operation, i.e., pond level fluctuations were not considered in calculating blowdown temperatures and evaporation rates.

The pond was conceptualized as composed of a surface layer and a bottom layer. Horizontal temperature distribution across the pond was approximated by spatial temperature variations in the surface layer. The bottom layer temperature was assumed to be uniform. Pond volume was assumed to be constant.

A schematic of the mathematical model that simulates cooling pond thermal performance is shown in Figure 8. The development of the transient cooling pond mathematical model closely followed the principles outlined by Ryan and Harleman (Reference 10) and incorporates the following assumptions:

S3178183

i. All interfacial mixing between the layers can be lumped at the pond entrance via a constant entrainment ratio.

ii. Circulating water system discharge and flow entrained from the bottom layer are fully mixed before advancing into the pond.

iii. Flow advances through the surface layer as a plug.

iv. At the pond outlet, the flow leaving the pond is uniform with depth.

v. Brady's wind speed function is used. This wind function is conservative for wind speeds between 5 mph to 10 mph, and thus generates higher than expected pond temperatures.

vi. All heat exchange with the environment is through the pond surface and includes solar and atmospheric radiation, back radiation and evaporative and sensible heat losses.

Local climatological data at Flint, Michigan from January 1, 1949 to September 30, 1977 were used to calculate daily cooling pond blowdown temperatures and evaporative water losses for the same period. The meteorological data used included: dry bulb temperature, wind speed, relative humidity, cloud cover and solar insolation. The first four parameters were directly available from the National Oceanic and Atmospheric Administration (NOAA) in the form of Tape Data Family-14.

Daily values for solar insolation were computed from clear sky solar insolation values (reported in Reference 11) and daily cloud cover values. Physical parameters of the cooling pond, such as surface area, depths of surface and bottom layers, and entrainment ratio were obtained or estimated from information in References 5 and 12. The heat load from the plant to the pond is 3370×10^6 Btu/hr when reactor Unit 1 is operating at back end limited condition and Unit 2 is shut down for refueling, 5680×10^6 Btu/hr when reactor Unit 2 is operating at valves wide open condition and reactor Unit 1 is shut down for refueling, and 9050×10^6 Btu/hr when Unit 1 is back end limited and Unit 2 with valves wide open. The refueling period was assumed to be April for Unit 2 and September for Unit 1. A constant circulating water flowrate of 1457 cfs was assumed for the entire year. The computed daily cooling pond blowdown temperatures for water year 1976 are shown in Figure 5. The 1976 temperatures and evaporation rates were used repeatedly from 1937 to 1948 where meteorological data was not available.

5. METHOD OF SIMULATION

Simulation of the cooling pond operation was performed on a daily basis. The simulation period was 29,950 days, starting at the last day of water year 1977 and running backward to the first day of water year 1937, then running forward from 1937 to 1977. This doubling of the simulation period provide an opportunity to check if pond TDS concentration and water depth stay within acceptable limits over the 1949-1937-1949 period where river flows were frequently low.

For each day, the natural river temperature was compared with the maximum temperatures listed in Chapter 2, Section 3-a. No blowdown was discharged if the natural river temperature was within 5°F of the maximum temperature for the same month. Next, the river TDS concentration after full mixing of Dow's effluent was computed from a mass balance computation. If the computed concentration were above 500 ppm no blowdown was discharged for that day. Then a permissible blowdown flowrate was calculated on the basis of not to increase the average river TDS beyond 500 ppm. A second permissible blowdown flowrate was computed from thermal plume considerations. The minimum among the two permissible flowrates was chosen as the upper limit on blowdown flowrate. A tentative blowdown flowrate was then calculated according to operational assumptions "e" and "f", (Sec. 3.2) and compared with the upper limit. The smaller of the two was chosen as the calculated daily average blowdown flowrate. If the calculated flowrate was below the minimum flowrate of 5 cfs, no blowdown was discharged.

A daily average makeup flowrate was computed from pond water surface elevation, river flow, and water losses due to evaporation, seepage and blowdown according to operational assumptions "b" and "f" (Sec. 3.2). No lower limit on makeup flow was used in the simulation since small makeup flowrates are of the same magnitude as daily evaporation rates of approximately 10 cfs during refueling periods.

Pond TDS concentration and water surface elevation at the end of each day were calculated from daily evaporation and seepage rates, daily flowrates, TDS concentrations of makeup and blowdown, pond volume, and TDS concentration for the previous day, according to the principle of conservation of mass.

It should be noted that Figure 7 provides only maximum blowdown flowrates at 5 different river flows. Linear interpolation according to river flow was used to estimate the maximum blowdown flowrate for river flows (after makeup withdrawal) equal to 1620 cfs, 2475 cfs, and 3200 cfs. The new set of curves is shown in Figure 9. For a given day, the permissible blowdown flowrate from thermal consideration was obtained from the curve of Figure 9 with the exact or next lower river flow. For example, for a river flow (after makeup withdrawal) of 2100 cfs and a blowdown excess temperature of 25°F, the allowable blowdown was read from the 2000 cfs curve as 30 cfs. This procedure tends to yield smaller (and thus conservative) maximum blowdown flowrates, especially when the blowdown excess temperature is below 15°F and the river flow is higher than its average value.

6. RESULTS AND DISCUSSION

The cooling pond operation was simulated by employing the available data as described in Chapter 4. This simulation constitutes the Base Case of the study. To evaluate the sensitivity of pond TDS concentrations and water surface elevations the following cases were also investigated:

<u>Case 1</u>: Simulation with base case data except the maximum blowdown flowrate is limited to 150 cfs instead of 220 cfs.

<u>Case 2</u>: Simulation with base case data except the minimum blowdown flowrate is set at 10 cfs instead of 5 cfs.

<u>Case 3</u>: Simulation with base case data except the daily ambient river TDS concentrations are increased by 20%.

<u>Case 4</u>: Simulation with base case data except the daily blowdown temperatures are increased by 5°F.

<u>Case 5</u>: Simulation with base case data except the daily evaporation rates are increased by 10%.

6.1 Base Case

Because of the large volume of the 880 acre pond, daily variations of pond TDS concentration and water surface elevation are small. Therefore, to facilitate visualization, monthly averages of pond TDS concentrations and water surface elevations, computed from daily values, are plotted in Figures 10 and 11 to demonstrate long term trends. In general, high pond TDS periods occurred during low river flow periods. The 82 years of simulation period conservatively doubled the low river flow period of 1937 to 1949. Because the simulation period is long, the initial pond TDS concentration and pond water level (physical assumption "g", Sec. 3.2) is not crucial to the results.

The peak pond TDS concentration of 2222 ppm occurred on September 6, 1942. The pond TDS concentrations and water levels for the dry period containing this peak day are shown in Figure 13. Daily average river discharges and makeup and blowdown flowrates for the same period are shown in Figure 14. The pond TDS concentration increased at a rate of approximately 9 ppm per day for this period when no blowdown and very little makeup could be made. The pond water surface elevation dropped approximately one inch per day for the same period.

The frequency curve for the daily pond TDS levels is shown in Figure 15. The median TDS concentration was approximately 840 ppm. The circulating water system and service water system hardware nominal design average and maximum TDS concentrations of 1206 ppm and 1832 ppm were equaled or exceeded 14% and 0.2% of the time respectively.

The frequency curve for daily average makeup flowrates is shown in Figure 16. With the physical and operational assumptions used in the simulation, approximately 86% of the time river water was pumped into the pond for makeup. From the daily river flow frequency curve of Figure 3, daily river flows also equaled or exceeded 390 cfs 86% of the time. The river flow of 390 cfs represents an assumed cutoff point below which no makeup is withdrawn from the river (see Figure 4). Therefore, water was pumped into the pond whenever the river flow was above 390 cfs. However, the full amount of available water for makeup was not generally utilized. This can be seen by noting that the available makeup flowrate is 210 cfs when river flow exceeds 1000 cfs (Figure 4). From Figure 3, daily river flows exceeded 1000 cfs 42% of the time. Corresponding to this 42% frequency, the makeup flowrate was only 38 cfs as shown in Figure 16, considerably smaller than the available 210 cfs.

The frequency curve for daily average blowdown flowrates is shown in Figure 17. Only about 27% of the time the Midland Plant used the Tittabawassee River as the receiving water body for its pond blowdown discharge. Typically little blowdown occurred in summer months.

Figure 18 shows the frequency of pond water surface elevations. The pond was full approximately 70% of the time. A margin of more than 2 ft. existed between the lowest simulated pond level and the minimum operating level of 618 ft.

Monthly average river discharges, evaporation plus seepage, makeup, blowdown, and pond TDS concentrations for the "average year" defined from the 82 years of simulation are shown in Table 2.

SB178190

Table 2

Monthly Flowrates & Pond TDS Concentrations for Average Year

Month	River Flow (cfs)	Evaporation & Seepage (cfs)	Makeup Flow (cfs)	Blowdown Flow (cfs)	Pond TDS Concentration (ppm)
Jan	1316	20.8	30.3	9.6	863
Feb	1630	21.8	34.8	12.7	856
Mar	3835	25.7	66.9	41.2	838
Apr	3612	30.2	70.6	35.7	850
May	2126	30.2	70.6	35.7	850
Jun	1296	38.3	60.4	15.4	892
Jul	735	39.2	35.7	4.9	919
Aug	551	38.3	28.0	2.3	922
Sep	692	25.9	32.0	4.2	912
Oct	802	29.6	33.0	2.6	909
Nov	1153	27.2	36.3	4.2	891
Dec	1260	21.5	29.6	6.0	872

Also of interest is the severity of various constraints imposed on the pond operation. Based on the data and assumptions described in Chapters 3 and 4, the cooling pond operation study indicated the following: 50% of the time blowdown was withheld because Dow effluent uses the whole TDS capacity of the river; 8.3% of the time blowdown could not be discharged because natural river temperatures were within 5°F of the monthly maximum temperatures set by MWRC; 13% of the time the calculated blowdown flowrates were below the preset minimum blowdown flowrate of 5 cfs and no blowdown took place; 1.6% of the time the pond water level was below 626.5 ft. and no blowdown was discharged. High blowdown TDS concentrations caused suspension of the blowdown discharge only 0.06% of the time. When blowdown took place, 24% of the time its flowrate was limited by thermal plume considerations in the Tittabawassee River and 3% of the time was limited by the blowdown system capacity of 220 cfs.

6.2 Sensitivity Analyses

Case 1: The effect of the capacity of the blowdown system on pond TDS concentration was investigated by reducing the capacity from 220 cfs to 150 cfs. This condition may correspond to the situation where one of the three blowdown pipes is out of service during high river flow periods. The monthly average pond TDS concentrations thus computed are compared in Figure 19 with those of the base case. It can be noted that the TDS concentration increased by approximately 80 ppm on the average. The nominal design average pond TDS level (1206 ppm) was exceeded 20% of the time in this case, an increase of 7% from that of the base case. The nomianl design maximum pond TDS level was exeeded 0.4% of the time.

Case 2: The effect of the minimum blowdown flowrate on pond TDS concentrations was studied by increasing its minimum value from 5 cfs to 10 cfs. The comparison of the resulting monthly pond TDS values with those of the base case is shown in Figure 20. It is seen that the pond TDS concentration was not sensitive to the 5 cfs increase. From Figure 17, the blowdown flowrate was between 5 cfs and 10 cfs for only approximately 3.7% of the time. This infrequent occurrence of blowdown flowrates in the range considered explains why the pond TDS concentration was not sensitive to the blowdown flowrate lower limit.

Case 3: In the operation study the daily natural river TDS concentrations used were only availablo for water years 1976 and 1977. Although the annual average TDS concentrations for these two years were comparable, the daily values plotted in Figure 6 were frequently quite different.

SB178192

Thus the use of daily TDS values of water year 1976 repeatedly over the 81 years simulation, although it represented the best utilization of available data, might not be conservative for some periods. Case 3 employed daily river TDS concentrations increased by 20% from their 1976 values. The resulting pond TDS concentrations shown in Figure 21, were found to be higher than those of the base case but still within acceptable level. The percent of exceedance for the nominal design average and maximum pond TDS concentrations were found equal to 31% and 5.5% of the time respectively.

Case 4: The blowdown excess temperature was calculated from the temperature of the blowdown and the natural river water. Those two quantities were in turn estimated from meteorological data. The overall accuracy of blowdown temperatures computed this way was estimated to be approximately 5°F. As shown in Figure 22, the effect of a 5°F increase in blowdown temperature on the cooling pond TDS concentration was an increase of 100 ppm. However, during prolonged low river flow periods when the TDS concentration of the cooling pond was high, an increase of 5°F in blowdown temperature could cause the cooling pond TDS level to increase by approximately 300 ppm. The nominal design average and maximum TDS concentrations were exceeded 24% and 1.4% of the time respectively.

Case 5: The accuracy in computing daily average evaporation rates was estimated to be about 10%. Thus the effect of possible higher evaporation rates on pond water surface elevations was investigated by increasing the daily evaporation values used in the base case by 10%. Results are shown in Figure 23 where it can be observed that

60% of the time the pond water level was not affected by the increase in evaporation rate. However, additional makeup water was withdrawn from the river to compensate for the increased pond evaporative water loss. Lower pond water levels occurred in Case 5 only when makeup water was not available due to low river flows. However, sufficient margin still existed between the low pond level computed with the increased evaporation rates and the minimum pond operating level of 618 ft.

In summary, the results of the base case together with the limited sensitivity analyses demonstrate that it is feasible to control pond TDS concentration and pond depth within acceptable limits. The applicable Michigan Water Quality Standards are satisfied since they were incorporated into the assumptions of this study.

8178194

7. CONCLUSIONS

The following conclusions can be drawn from the results of the simulation of the cooling pond operation:

a. It is feasible to control the pond TDS concentration through use of the makeup-blowdown system. Based on the assumptions and the available data set forth in Chapters 3 and 4, the resulting pond TDS concentrations are acceptable for the circulating water and service water system hardware. Cooling pond water surface elevations also remain above the minimum pond level of 618 ft. for the period of simulation.

b. The blowdown discharges into the Tittabawassee River can be made in compliance with the Water Quality Standards of Michigan Water Resources Commission.

c. In this study, the Dow Chemical Company's effluent discharge had priority over the Midland Plant cooling pond blowdown. As a result, the total dissolved solids in Dow's effluent severely limited the occurrence of cooling pond blowdown discharge.

d. On a long term basis, cooling pond blowdown and the resulting thermal plumes will exist in the Tittabawassee River for about 27% of the time. For the remaining time, there will be no blowdown discharge.

e. Based on the assumptions and the available data used, the operation of the makeup-blowdown system is limited by its ability to blowdown due to thermal plume considerations. There is adequate amount of water for pond makeup from the Tittabawassee River, and there is no significant effect on river flows because of plant makeup withdrawal.

The simulation of the cooling pond is performed on an average daily basis while river flows are known to vary considerably within one day. The transient river discharge is caused by water releases from the upstream Sanford Dam. An example of such variation is shown in Figure 24. The river flow changes observed on April 22, 1977 are typical for weekdays. The river flow approaches a steady state on Saturday and Sunday since no flow is released form the dam. Due to the wide range of river flow variation within a short time period, a control system to regulate the blowdown discharge in phase with the varying river flow is desirable.

SB178136

REFERENCES

1. Environmental Report, Operating License Stage. Midland Plant Units 1 & 2, Volume 2, Section 3.4 Consumers Power Company, November 1978.

2. Circulating Water System Description, 7220-SD-M-46, Revision 0.

3. Michigan Water Resources Commission General Rules, Part 4 - Water Quality Standards, Approved September 21, 1973, Effective December 12, 1973.

4. Climate of Michigan by Stations, Michigan Department of Agriculture and Michigan Weather Service, Second Edition. December 1971.

5. Cooling Pond Thermal Performance Summary Report, Midland Plant Units 1 & 2, Prepared for Consumers Power Company, Bechtel Incorporated, San Francisco, August 1973.

6. Water Resources Data for Michigan, Water Years 1937 through 1977, 41 Volumes. U. S. Geological Survey Water-Data Report.

7. "Use of Air-Water Relationships for Predicting Water Temperature" by V. Kothandaraman and R. L. Evans. Report of Investigation 69, Illinois State Water Survey, Urbana 1972.

8. Final Safety Analysis Report, Midland Plant Units 1 & 2, Section 2.3.3.9.2, March 1978.

9. "Investigation of a Thermal Plume in a Shallow River - Hydrothermal Model Studies of Cooling Pond Blowdown Discharge, Midland Nuclear Power Station", Alden Research Laboratory, Worcester Polytechnic Institute, Holden, Massachusetts, April 1979.

10. "An Analytical and Experimental Study of Transient Cooling Pond Behavior" by R. J. Ryan and D. R. F. Harleman, R. M. Parsons Laboratory Report No. 161, January 1973.

11. Hamon, R. W., Weiss, L. L., and Wilson, W. T., "Insolation as as Emperical Function of Daily Sunshine Duration", Monthly Weather Review, Volume 82, No. 6, 1954.

12. Model Study - Midland Cooling Pond by Alden Research Laboratories, January 1970.

S3178197

Austin Marshall
C.E.W.

2-16 ...79

BA + PL subs. measurements. C722C

Due to the necessity for raising the BA+PL Rods in advance of the dirt fill, we are experiencing increasing difficulty in obtaining elev. measurements with the accuracy we normally would hope to achieve. Most of these now have to be measured by extending a 8' rule downward from the top of the rod & hence are not as accurate as a reading with a level rod. With the present conditions, the indicated accuracy will be in the order of ± 1/4".

S3178760

CALCULATION SHEET

DESIGN BY C.E.W. DATE 3-22-79 CHECKED BY ______ DATE ______ SHEET NO. ______

PROJECT D. G. Bldg Subs. Program JOB NO. ______

SUBJECT extension of interior BA, PL + PD rods CALCULATION NO. ______ FILE NO. ______

On 3-19-79, all rods were extended above the 664 floor in Bay three and four and on 3-20-79, the rods in Bays one and two were extended with the exception of BA 46, BA 47, BA 48, BA 59, BA 60 and PL- which were initially installed in locations that placed them beneath the upper walls. These six rods cannot be monitored upon placement of additional surcharge, but will be capped and monitoring will be resumed upon re-excavation to this elevation. Elevations were recorded prior to extension by a survey crew while a second survey crew recorded the elevations subsequent to extension. At this time, the elevations of settlement points DG 4 through DG 19 were also recorded for to-date settlement. Further pedestal settlement will be ascertained by monitoring the P.D.s.

As all of the protecting pipe was not installed with the 1/2" rod, some of the initial upper readings will show some minor discrepencies due to the flexing of the unsupported rods. The remainder of the protecting pipe is now installed and additional readings will be taken prior to additional surcharge. The higher readings should be regarded as the initial zero settlement point. Accuracy of subsequent readings should be no more than ±.0 when surcharge is completed.

S3178761

CANONIE CONSTRUCTION CO. / P.O. BOX 509 / U.S. 31 & M-43 / SOUTH HAVEN, MICHIGAN 49090 / (616) 637-1171

May 3, 1977

RECEIVED
MAY 9 1977
BECHTEL POWER CORP.
JOB 7220
PER 154(E) C-210

Mr. John Church
Subcontracts Department
Bechtel Power Corporation
P.O. Box 2167
Midland, Michigan 48640

Subject: Consumers Power Company
Midland Station Units 1 & 2
Bechtel Power Corporation Subcontract #7220-C-210
Plant Foundation Excavation and Cooling Pond Dikes
Canonie Construction Co. Quality Assurance Program
dated August 1976
Addendum dated 4/5/77, Rev. 3

Reference: Contract Change Notice 44-F, Ser # C-210-B-190, dated 4/21/77
Letter dated 6/29/76, J. F. Newgen to Canonie Construction Co.
Letter dated 9/14/76, J. F. Newgen to J. McKane

Dear Sir:

In response to the referenced letters above, Canonie Construction Co. submits for your review, comment, and acceptance the attached addendum to the subject Canonie Construction Co. Quality Assurance Program. This addendum shall be applicable for all work covered by the above referenced subcontract for the scope of work defined in the referenced specification.

Work requiring the implementation of the Quality Assurance Program is defined in Exhibit D, Technical Specification for Plant Foundation Excavation and Cooling Pond Dikes, of the subject subcontract specification. The Quality related activities so defined are as follows:

A. Placement of plant area backfill and berm backfill. Backfill is defined by section 13.2 of the referenced subcontract.

B. Moisture control of the plant area and berm material to verify conformance to the provisions of section 12.6 of the referenced subcontract.

C. Compaction requirements for backfill in the plant area and the berm to be in compliance with Bechtel requirements stated in section 13.7 and 12.8 of the referenced subcontract.

SB178774

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JUN 23 1977
BECHTEL POWER CORP.
JOB 7220

Mr. John Church
Page 2
May 3, 1977

Further, to assure the successful execution of the above referenced subcontract in compliance with all owner/architect/engineer-constructor requirements, the attached addendum shall be in effect until such time as it is revised or terminated in order to affect the successful implementation and completion of all work.

W. R. Moore

W. R. Moore
Quality Assurance Engineer,
Canonie Construction Co.

W. R. Moore for J. K. McKane

J. K. McKane
Vice President,
Earthmoving Division;
Manager of Quality Assurance,
Canonie Construction Co.

WRM/bw

Enclosures (1/1)

cc: J.K. McKane

SB178775

CANONIE CONSTRUCTION CO

APPROVAL	DATE
W.R. Moore	5/3/7
WRM for Jack McKinn	5/3/77
REVISION	

7220-C210-3-2

F-7220-C210-1-4

 Date: 4/5/77
Rev: 3

Addendum to: Canonie Construction Co.
Quality Assurance Manual
Dated, August, 1976

Contract: Bechtel Subcontract
No. 7220-C-210

Location: Midland Station Units 1&2
Midland, Michigan

Owner: Consumers Power Company

Title: Supplemental Requirements for the Canonie Construction Co
Quality Control Program for Q Listed Areas

MAY 1 6 1977

SUPPLIER DRAWING REVIEW

1 [X] Approved – Mfg. may proceed.
2 [ ] Approved – Submit final dwg. – Mfg. may proceed
3 [ ] Approved except as noted – ...
4 [ ] Not approved – Submit and resubmit ...
5 [ ] Approved for records – Mfg. may proceed

[ ] INFORMA...

5-23-77

...AL CORPORATION

SB178776

CANONIE CONSTRUCTION CO.
SOUTH HAVEN, MICHIGAN

SB178777

Item I, changes:

Add to para. 2, section 1.0, Introduction:

The Quality Assurance manual shall be supplemented by Quality Control procedures written to clarify and further implement the Quality Assurance program of Canonie Construction Co. Prior to site implementation, these procedures shall be approved by the Manager of Quality Assurance, Canonie Construction Co. and the Contractor or appropriate owner's representative. All Quality Control procedures shall be controlled in the same manner as the Quality Assurance program and revisions and addenda shall be reviewed and approved in the same manner as originals. These procedures shall indicate the scope of activities covered therein, the personnel designated by said procedures with responsibilities by job title, and shall provide sufficient instructions to clearly indicate what activities are necessary to demonstrate compliance with the accepted Quality Assurance program.

Delete para. 3, section 2.4 as written and insert:

The Quality Control Engineer shall have the authority to stop the continuation of work that is deficient in characteristic, documentation, or procedure which renders the quality of an item unacceptable or indeterminant. This shall include, but not be limited to physical defects, test failures, incorrect or inadequate documentation, or deviation from prescribed processing, inspection or testing procedures.

Delete sentence 1, para. 4, section 3.1 as written, and insert:

Activities which may be routinely performed by Canonie Construction Co. as part of inspection services on a project, such as concrete testing, structural earthwork control or testing of reinforcement steel, shall be conducted to recognized standards or referenced specifications.

Delete sentence 4, para. 2, section 3.2.3 as written and insert:

Revision receipts shall be signed and dated by the assignee, or designated representative, and returned to the Manager of Quality Assurance within 15 days of receipt.

Delete sentence 4, para. 3, section 3.2.3 as written and insert:

A new approval sheet, signed by the President, Canonie Construction Co. and the Manager of Quality Assurance, shall be issued to indicate the current revision number and date of the manual issue in effect. This shall indicate Canonie Construction Co. acceptance of the policies and procedures defined therein.

Delete sentence 2, para. 1, section 3.4.2 as written and insert:

A file of all Quality Assurance/Control records shall be maintained to comply with all owner/constructor contractually specified requirements. These records shall be maintained as required by this manual and applicable code and regulatory requirements.

Delete sentence 2, para. 1, section 4.4 as written and insert:
For all the various activities included in the scope of work for the referenced specification,

Item II, Supplements:

1.0 Organization
The Canonie Construction Co. Quality Control Organizational interface with the Bechtel Power Corp. is shown in figure 1.

1.1 The Project Manager performs overall site supervision to ensure that construction schedules are maintained and that the work is performed in compliance with drawings and specifications. He coordinates work with the site Quality Control Engineer to assure compliance to the accepted quality program.

1.2 The QC Engineer has responsibilities and duties as follows:

1.2.1 He will document the classification of the borrow by the Testing Laboratory to the Project Manager for use by the Field Foreman.

1.2.2 Based on borrow selections he prepares daily reports verifying by station, by zone, the fill placement, the moisture control, and the compaction conformance necessary to meet specs.

1.2.3 In this function, he is completely mobile and will by available for comment from the General Contractor's inspection force. He will be in communication with the Project Manager to correct any deviations in the fill requirements as established by the project specifications.

1.2.4 The Quality Control Engineer has the authority to assure total compliance to the Quality Assurance/Quality Control program by all Canonie Construction Co. personnel.

1.3 The Field Superintendent shall initiate compliance with the borrow/cut programs as outlined by the QC Engineer through the Project Manager. He shall be responsible for reporting field production requirements to the Project Manager.

1.4 The Project Engineer shall work closely with the project manager and QC Engineer to establish survey and control methods required to assure proper definition of zone fills and lift controls.

2.0 Quality Control Program

2.1 The Quality Control Team or member shall be responsible for quality control and documentation for all Q Listed areas as designated by contractor's and/or owner's specifications. The inspection unit shall assure that the project specifications are strictly enforced. Qualified and experienced personnel shall comprise the inspection force.

2.2 The Quality Control Engineer and/or his representative shall be responsible to the Canonie Construction Co. project QC manager and shall be independent of production, construction, scheduling and procurement.

2.3 The QC Engineer shall develop, in the course of his duties and as required, adequate forms, charts and logs to compile and assimilate required QC information and documentation of Q listed work.

2.4 All QC Records and Documentation shall be stored in a fire resistant filing cabinet. The records shall identify the inspector or data recorder, the activity monitored, date of inspection or test, test results, acceptability and any corrective action required or taken. This information shall be supplemented as required.

2.4.1 The On Site Records shall be filed in an orderly fashion and shall be readily identifiable and retrievable. Upon completion of construction work, records shall be turned over to the owner's operations group or his designated representative.

2.5 The QC Engineer shall assure that the proper zoned materials are delivered to the proper location and the proper compaction control is performed as required by the specifications.

2.6 The QC Engineer shall schedule his work so that all operations, reports, documentation and related items shall be available to the contractor and/or owner and to facilitate the establishment of a functional interface between the appointed testing laboratory, general contractor and field superintendents.

2.7 The QC Representative shall become familiar with the testing laboratory personnel testing methods and individual soil classification characteristics.

SB178780

2.8 The QC Engineer's level of authority shall be equal to the highest ranking production unit ie. supervisor or superintendent. The QC Engineer does not direct work forces, except through supervisory personnel, and then only in quality related areas to insure compliance with job specifications, procedures, and drawings.

6.0 Document Control

6.1 Index Card File System

6.1.1 Individual Card for Each DWG shall be maintained listing:

DWG Title and Number

Revision Number
Revision Date
Date Received
Number Received
Classification: Preliminary or Approved
Distribution: Stick Number or Name of Person drawing is issued to

6.2 A Drawing Summary List shall be maintained listing:

Stick Number
Drawing Number
Title
Revision and Date
Status: Preliminary or Approved

6.3 Drawing Awareness
New or revised drawing will be routed to assure all personnel concerned are aware of change. A list of document assignees shall be maintained to assure proper distribution.

6.4 Separate storage of Superseded Drawings and Specifications to Maintain Adequate Control shall be provided. All superseded documents shall be voided.

6.5 Document control shall not be confused with documentation control. It is not intended that document control shall be specifically a function of the quality control Engineer. An authorized agent of the QC Department may perform the document control function. Documentation shall be a function of the QC Engineer and shall show all pertinent information as required by contractor's specifications.

8.0 <u>Identification and Control of Materials, Parts and Components</u>

8.1 <u>The QC Representative</u>, working with the general contractor's representative, shall inform subcontractor's field supervision force of soil classifications in borrow areas as designated by the testing laboratory.

15.0 <u>Non-Conforming Materials, Parts or Components</u>

15.1 <u>Compaction Equipment</u>

15.1.1 The utilization of dissimilar compaction equipment outlined in exhibit D of 7220-C-210 shall be as follows:

15.1.2 The owner's testing laboratory shall be requested to perform tests on controlled test-fills within the embankment as required to determine pass requirements for each individual type compactor.

15.2 <u>Backfill Materials</u>
In the event that non-conforming materials are discovered in borrow areas by the testing laboratory, the contractor shall be notified for disposition. Non-conforming material shall be removed and/or disposed of as required by contractor.

16.0 <u>Corrective Action</u>
When corrective action is required the following outline of activities shall be followed:

16.1 Identification of source of non-conformance.

16.2 Evaluation of causes, conditions, present requirements and potential solutions.

16.3 Implementation of corrective action.

16.4 Contractor and/or testing laboratory analysis of problem is required if caused by external, uncontrollable sources, ie. excessive precipitation causing moisture content of cohosive soils to exceed acceptance criteria and preclude conformance to compaction requirements.

16.5 When internal corrective action is required, it shall be documented for review and concurrence by the QA Manager. If the causes of non-conforming conditions are external and outside the specified jurisdiction of the subcontractor, recommended corrective action shall be requested of the contractor and/or his agent, and shall be concurred with by Canonie site quality control.

16.6 Documentation as required by owner shall be maintained in accordance with document control procedures.

17.0 <u>Quality Control Records</u> shall be compiled and submitted to Bechtel for their review and retention. Copies shall be maintained by Canonie Construction Co. and shall include related data such as qualifications of personnel, procedures, and equipment. Consistent with applicable regulatory requirements, the owner/contractor shall establish requirements concerning record retention and turn-over, such as record detail and type, and systems effected. Canonie Construction Co. Quality Assurance shall be notified in writing of any and all changes in documentation requirements.

17.1 The following forms shall be used to document the implementation of quality program on site.

17.1.1 <u>Lift Thickness Control - Figure 2</u>
By determining elevation before and after placement operations from grade stakes, the QC Engineer shall determine the lift thickness achieved. He will prepare a report from information listing the following data:

Observation
Zone
Work Location
Size of Area
Elevation(s): Before
After
Lift Thickness
Date

These random lift thickness checks shall be performed on an average of two areas daily depending on the working area conditions and the materials classification.

17.1.2 <u>Compaction - Figure 3</u>
On a daily basis the QC Engineer shall prepare

a report for each zone and work area listing the following information: date, shift, weather, features, foreman, station, offset, elevation obtained, results of roller speed checks, equipment numbers, type, and frequency checks including vibration rate checks and time taken, and load counts.

17.1.3 Borrow Acceptance - Figure 4
The QC Engineer will obtain classification of material from the Bechtel representative and/or the testing laboratory.

17.1.4 Deficiency - Corrective Action - Figure 5
When notified by the Bechtel representative that a deficiency exists the QC Engineer shall note the date, time, feature, location, shift, foreman, elevation, and type of deficiency, ie. failing test. He shall notify the project manager or his representative and corrective actions shall be implemented. After corrective action implementation, a new test shall be performed and the results noted. Where necessary, further corrective action shall be instituted.

17.2 Quality Assurance/Control Records
All the aforementioned reports shall be compiled and submitted to Bechtel for their review and retention. Copies shall be maintained on file by Canonie Construction Co.

18.0 Audits
A system of planned, periodic, and documented internal audits has been established to verify compliance with all aspects of the accepted quality assurance program.

18.1 Audits shall be performed in accordance with written check lists by personnel qualified and trained in the performance of audits and familiar with the scope of work being performed.

18.2 Audit personnel shall be selected to preclude the possibility of personnel participating in audit activities in areas where they have direct responsibility.

18.3 Audit results are documented and reviewed by management personnel having responsibility for the areas being audited.

18.4 Corrective action is implemented to correct deficiencies revealed by audit activities, and to correct system inadequacies determined to be the cause for significant conditions adverse to quality.

18.5 Audit results and corrective actions are reviewed by upper management to determine the effectiveness of the audit program in correcting conditions adverse to quality and to verify the implementation of corrective action.

CANONIE CONSTRUCTION CO.
SOUTH HAVEN, MICHIGAN

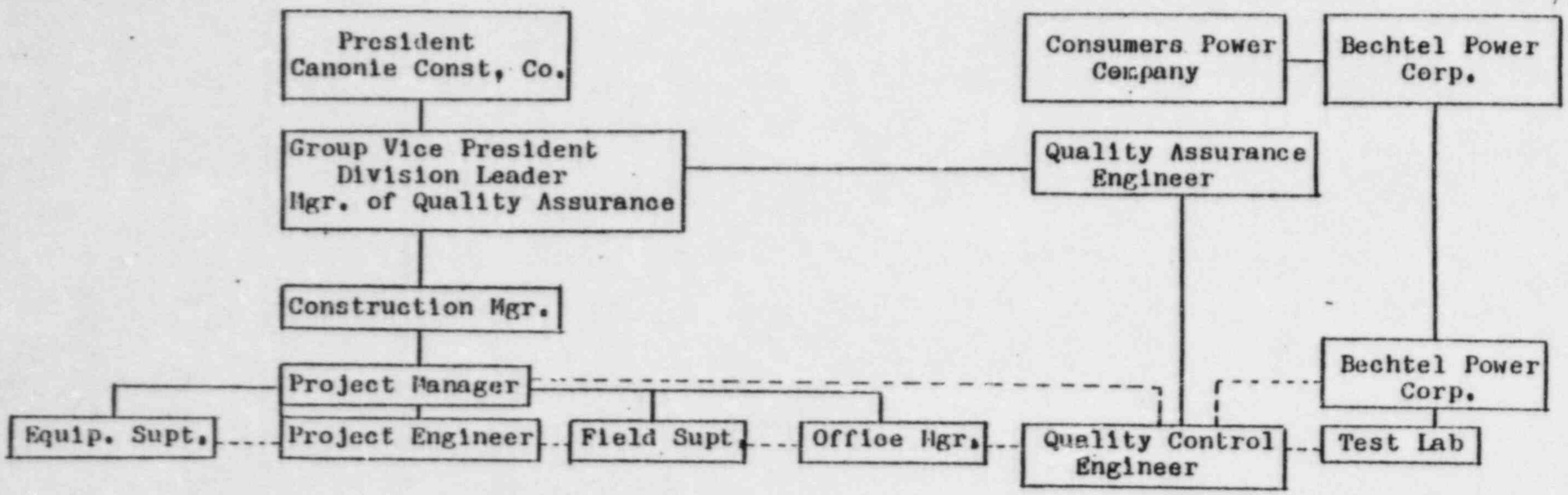
18.6 Where necessary to establish objective evidence of implementation, corrective action shall be verified by the performance of re-audits of those areas previously determined to be non-conforming.

SB17S784

Canonie Construction Co.

Midland Station Units 1&2

Plant Foundation Excavation & Cooling Pond Dikes



——— Direct Responsibility

--------- Communication

Figure 1
Rev. 3, dated 4/5/77

SB178785

CANONIE CONSTRUCTION CO.
SOUTH HAVEN, MICHIGAN

Figure 2
Rev. 1, 7/26/73

MIDLAND NUCLEAR UNITS 1&2
CANONIE CONSTRUCTION CO.

P.M.________
G.S.________
F.S.________
____

LIFT THICKNESS CHECK

OBSERVATION NUMBER:________________ DATE:____________

ZONE:____________________________ LENGTH:____________

STATION:__________TO STATION:__________ WIDTH:____________

OFFSET:__________________________

ELEVATION: BEFORE__________ AFTER__________ LIFT THICKNESS____________

BEFORE__________ AFTER__________ LIFT THICKNESS____________

BEFORE__________ AFTER__________ LIFT THICKNESS____________

BEFORE__________ AFTER__________ LIFT THICKNESS____________

AVERAGE LIFT THICKNESS____________

REMARKS/SKETCH:

BY:________________________
CANONIE CONSTRUCTION CO.
QC REPRESENTATIVE

SB178786

Figure 3
Rev. 1, 7/26/73

Canonie Construction Co.
South Haven, Michigan

MIDLAND NUCLEAR UNITS 1&2
CANONIE CONSTRUCTION CO.

P.M.__________
G.S.__________
F.S.__________

FILL PLACEMENT QA-QC DAILY REPORT

FEATURE:
( ) EMERGENCY COOLING POND BERM
( ) PLANT AREA FILLS
( ) R/R EMBANKMENT
( ) LAYDOWN AREA
( ) COOLING POND DIKE

DATE:__________
SHIFT:__________
WEATHER:__________
FOREMAN:__________
ELEVATION:__________
STATION:__________ TO STA:__________
OFFSET:__________
MOISTURE TESTS:

ZONE:
( ) 1 ( ) 4
( ) 1-A ( ) 4-A
( ) 2 ( ) 5
( ) 3 ( ) 6

LOAD COUNT__________

COMPACTION EQUIPMENT:

EQUIP. NO.	TYPE	FREQUENCY	TIME	SPEED

REMARKS/SKETCH:

SB178787

BY:__________
CANONIE CONSTRUCTION CO.

CANONIE CONSTRUCTION CO.
SOUTH HAVEN, MICHIGAN

Figure 4
Rev. 2, 4/12/74

MIDLAND NUCLEAR UNITS 1&2
CANONIE CONSTRUCTION CO.

P.M.__________
G.S.__________
F.S.__________

BORROW PIT ACCEPTANCE

AREA:
( ) COOLING POND
( ) DIKE FOUNDATION

DATE:__________
GRID LOCATION:__________

MATERIAL:
( ) IMPERVIOUS ZONE 1
( ) IMPERVIOUS ZONE 1-A
( ) RANDOM

APPROXIMATE ELEV:__________

SKETCH:

The above area has been found to contain a suitable amount of material conforming to the requirements of the specification and, therefore, has been classified a borrow area.

It is understood that the borrow pit shall remain so designated until there occurs a marked change in the characteristic of the excavated materials.

SB178788

REMARKS:__________

BY:__________
BECHTEL POWER CORP.

BY:__________
CANONIE CONSTRUCTION CO.

Figure 5
Rev. 1, 7/26/73

Canonie Construction Co.
South Haven, Michigan

MIDLAND NUCLEAR UNITS 1&2
CANONIE CONSTRUCTION CO.

P.M.________
G.S.________
F.S.________

DEFICIENCY CORRECTIVE ACTION REPORT

DATE: ________ TIME: ________ SHIFT: ________

FEATURE: ________ FOREMAN: ________

LOCATION: ________ ELEVATION: ________

DEFICIENCY: ________

CORRECTIVE ACTION: ________

SUGGESTED PREVENTATIVE MEASURES: ________

CORRECTIVE ACTION QUALITY ASSURANCE:

TESTING: ________

OTHER: ________

SKETCH (IF REQ'D):

SB178789

BY: ________
BECHTEL POWER CORP.

BY: ________
CANONIE CONSTRUCTION CO.