FOIA

Docket No. 50-320

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THREE MILE ISLAND NUCLEAR STATION

UNIT 2

GROUNDWATER STUDY

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THREE MILE ISLAND NUCLEAR STATION UNIT 2

I. BACKGROUND

On March 28, 1979 an accident at Three Mile Island Nuclear Station near Middletown, Pennsylvania caused the staff to initiate a study. The purpose of this report and the associated study was to examine the groundwater regime in the area of Three Mile Island Nuclear Station.

II. OBJECTIVES

The objectives of the study were to (1) characterize the groundwater regime, (2) study the feasibility of isolating, and dewatering the groundwater regime at the reactor site, and (3) determine the potential for groundwater contamination offsite.

III. SITE CHARACTERISTICS

A. Stratigraphy

As illustrated in Figure 2.5-3 of the Final Safety Analysis Report (FSAR) (see bibliography) for Three Mile Island (TMI) Nuclear Station, the island is underlain by:

(1) Medium dense sandy silt with some gravel grading laterally to loose to medium dense sand and gravel directly under the reactor building (elevation 300 ft plus to 282 ft (mean sea level) msl with considerable bottom variations).

(2) Medium-dense to very-dense silty sand and gravel (elevation 282 ft to 277 ft msl with considerable upper variations).

(3) Medium hard to hard red siltstone known as the Gettysburg Formation of the Newark Group of Triassic Age (bedrock elevation 277 ft msl with relatively uniform surface).

The interface between the Gettysburg Formation and overlying unconsolidated materials has 1 to 3 feet of weathered rock.

Regionally, the bedrock strikes N 65°-80°E and dips 35° to 70° to the northwest. (FSAR Section 2.5.1.2.2 p. 2.5-3). Drill cores indicated a more consistent dip of 37 1/2 to 45° at TMI. (FSAR Section 2.5.1.2.2 p. 2.5-3). Previous investigations also discovered well developed, nearly vertical jointing along a N 10E trend with some joints healed and others altered by oxidation. (FSAR Section 2.5.1.2.2 p. 2.5-4)

One mile upstream, and 0.2 miles downstream are two easterly trending diabase intrusions that cut across the Gettysburg Formation. (see FSAR Figure 2.5-1)

The bedrock surface although generally uniform at elevation 277 ft msl does exhibit low swails at the southwest corner of the turbine building for Unit 2, and along the north wall of the diesel engine building for Unit 1. (See Figure 2.5-2)

B. Hydraulic Characteristics

1. Unconsolidated Materials

Previous site investigations using a pumping test indicated the hydraulic conductivity of the saturated soil zone on the eastern side of the island to be on the order of 10^{-2} cm/sec. A falling head test for similar material in the center of the island indicated a hydraulic conductivity of 10^{-3} cm/sec. (FSAR Section 2.4.13.2). The specific yield of the materials was not stated, however, it would probably fall between 0.10-.20 being highly dependent upon the silt content.

2. Bedrock

The Gettysburg Formation has highly directional transmissivities. Reported values range from 1,200 gpd per ft to slightly less than 50,000 gpd per ft. (FSAR Section 2.4.13.2.) The storage values are quite low since it is the jointing that contributes to the storage. A value of between 10^{-4} to 10^{-5} would be a reasonable guess at the storage coefficient. The vertical to horizontal hydraulic conductivity ratio was reported to be 1 to 100 (Wood, 1[illegible])*.

The anisotropic properties coincide with the regional bedrock strike of N 65°-80°E. Wells in the Gettysburg Formations have variable yields between 0 to 300 gpm depending upon the spacing and degree of jointing, and the presence of sandstone facies.

The diabase ridges to the north and south are relatively impermeable and are expected to have appropriately small hydraulic conductivity ($<10^{-7}$ cm/sec) and specific yield (<0.01).

C. Water Table Observations

The site has a water table at approximately 280 ft msl elevation depending upon the Susquehanna River stage normally at 277 ft msl. Site borings indicate the water table to vary 5 feet from a high at the island's center to the shores. The water table gradient is approximately 0.006 toward the river (FSAR Section 2.4.13.2). At the 20 observation points, the water depth ranged from 14 to 19 ft below surface datum with

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*References are listed in the Appendix.

corresponding saturated heads of 6.2 to 1 ft above the bedrock contact. (FSAR Section 2.4.13.2.)

The nearest potable water supplies are 3 wells located on the east bank of the Susquehanna directly across from TMI (Wood, 1979). The reported elevations of ground water in these wells in 1971 were from north to south:

1. 295 ft. msl with a surface measuring point (M.P.) of 315 ft. msl for Well DA-511 located 1300 ft from the bank .

2. 284 ft msl and surface M.P. of 340 ft msl, for Well DA-510 located 120 ft from the bank.

3. 300 ft msl and surface M.P. 315 ft msl for Well DA-523 located 200 ft from the bank.

D. Interrlationship of Groundwater to Surface Water Regimes

The Susquehanna River is a groundwater sink with a large portion of its discharge as base flow, and normally flows at elevation 277 ft msl.

The nearest heavily pumped wells are in Middletown which is north of the diabase ridge boundary and therefore are separated from the influence of the plant.

Further, nearby wells are not affected by site conditions because the hydraulic gradients slope away to the river, and the diabase ridges acting as no flow boundaries. The water table at TMI drains to the river. Although, it can be affected by high river stages which reverse the gradient and create bank storage, this was not the case during the period of this investigation.

The Gettysburg Formation has basic artesian characteristics in the site area since the flow is along bedding planes and joints. Groundwater flow is highly anisotropic along the strike direction with specific capacities ranging from 0.33 to 15.0 gpm per foot of drawdown. The leakage of ground water from the Gettysburg Formation would be anticipated to be upward but would vary considerably with the degree of jointing and relationship to strike direction. Therefore, effluents released in the plant should not migrate into the Gettysburg Formation.

III. Physical Plant

A. Unit 2 Reactor

The Unit 2 reactor is located on the northern third of TMI. The elevation of the reactor building floor is 280.5 ft msl on a concrete mat directly over the Gettysburg Formation. The reactor vessel floor is at elevation 291.5 ft msl. For reference, the water table elevation 280 ft msl.

B. Onsite Drainage

Storm drainage is provided within the diked area. Drainage culverts drain to the southeast where a storm drainage and flood control area is located. A system of pumps and an outfall pipe carries the drainage out into the east channel of the Susquehanna River.

C. Flood Protection Embankments

A system of embankments was constructed around the northern third of TMI for flood protection against the Probable Maximum Flood (PMF). The dike elevation is 305 ft msl on the western shore, 304 ft msl along the southern border and 310 ft msl at the northern point decreasing in height to 305 ft msl at the southeastern corner.

V. DEWATERING TECHNIQUES

A. Slurry Wall Containment

As a means for isolating contaminated surface and groundwater in the site area, the feasibility of constructing an impermeable membrane was studied. A slurry wall was thought to be the most efficient method of isolation.

1. Cement Bentonite (CB)

Based upon previous experience with the Bailly Generating Station, Nuclear 1, a cement bentonite slurry wall was investigated. Cement bentonite is used where slope support is needed for dewatering excavation sites (Siefkin, 1979). The cement bentonite requires 24 hours to cure. The bentonite can either be installed into 2-3 foot wide trenches up to 55 feet deep directly, or pumped by use of adapters to driven piles for depths greater than 55 feet. A clam shell dragline may be utilized for depths more than 30 feet, if only conventional backhoes are available. Special backhoe adapters are available from ECI for depths 30-55 feet and widths of 2-3 feet (Shallard, 1979).

Cement bentonite construction is a much slower and expensive process than for soil bentonite but provides added strength. With age the cement bentonite may crack (Shallard, 1979).

2. Soil Bentonite (SB)

Soil bentonite is more flexible and less expensive since the trenching spoil is used in the backfilling. SB is quicker to install but must be installed in a continuous fashion by a single backhoe and cementer unless the trench is keyed into a cement bentonite wall or impermeable feature (Shallard, 1979).

The native material can be used in the backfilling operation if it is sand and gravel preferably a poorly graded mixture. No curing time is required for the SB and dewatering can begin immediately after construction whereas CB requires 24 hours for curing prior to dewatering (Shallard, 1979).

Previous experience has shown that both CB and SB can be installed and be effective up to 110 feet in depth. With both SB and CB the ability to preclude ground water flow is based on the ability to key the wall into a no flow boundary. Minimum permeabilities for CB is approximately 10^{6} cm/sec. For SB the minimum permeabilities is 10^{-6} cm/sec for clean sands and gravel, and 10^{-8} cm/sec for reasonably well graded material such that 30% will pass a #200 sieve size (Shallard, 1979). At TMI the material ranged from a sandy silt with gravel to a silty sand with gravel.

Principal suppliers for bentonite, mined principally in South Dakota and Wyoming, are Baroid, Houston, Texas, and American Colloid, Chicago, Illinois. The speed of construction is highly dependent upon site conditions and availability of equipment, bentonite, and experienced workers. Based upon previous experience (Davis Besse Nuclear Plant near Oak Harbor, Ohio and James H. Campbell Coal Fired Plant near West Olive, Michigan) optimal conditions could allow 250 feet of SB construction per day per unit backhoe. (Shallard, 1979)

For the TMI site the fastest method for construction of the estimated 9200 foot slurry wall with numerous backhoes would be as follows:

a. Lay out a survey line for the slurry wall construction taking into consideration plant and site conditions.

b. On the first day construct numerous isolated 40 foot cement bentonite trenches spaced equally apart along the inside border of the flood protection dikes. Key into the Gettysburg Formation at or about 30-35 foot depth.

c. Construct numerous soil bentonite trenches between the CB trenches using the spoil as backfill such that the slurry wall ulitmately encloses the site. Key the SB trenches to both the CB trenches and the Gettysburg Formation.

V. DEWATERING SYSTEM

The first remedial action in the event of a class 9 accident would be to initiate installation of a dewatering system in the vicinity of the reactor building.

1. Well Points

A series of uniformly spaced well points along the eastern, western, and southern sections of the slurry wall to bedrock would sufficiently dewater the site. Based on preliminary investigations of the bedrock depressions, the optimal location for dewatering would be the areas between the turbine building for Unit 2 and the circulating pump house, and between the parking area and diesel engine building for Unit 1. The method of installation would be as outlined in basic texts (see Mansar, 1962) or by using a fire truck pumping unit jetting pipe with improvised steel wire mesh screen.

2. Gravity Drains With Pumps

Owing to the shallow (19 to 14 foot depth) and relatively thin (5.2 to 1 foot) saturated zone above the bedrock, a series of trenches with slotted pvc or terra cotta pipe with gravel backfill draining to a sump pump would also effectively drain the subject area. The areas noted in the "well points" discussion would be the optimal locations.

3. Deep Wells

In the event of a core meltdown the possibility of contamination to the deep aquifer is possible. However, due to hydraulic gradients and net upward leakage, the possibility of contamination of the deep aquifer beyond the limits of the island is highly unlikely.

However, to handle that contingency a series of deep wells located around the reactor into the bedrock to the south and west would effectively dewater any potential contaminants. Unless these actions were completed prior to meltdown, special precautions and construction techniques would be needed to safeguard the drilling crews. Additional discussion of precautionary measures is beyond the scope of this report. However, sufficient time would be available to accomplish such protection.

c. Surface Storage and Treatement

The dewatered discharge would be stored and tested prior to treatment and eventual removal or discharge into the Susquehanna River. The two cooling tower ponds would act as initial storage tanks with a series of secondary holding tanks for treatment and discharge. The choice of secondary holding tanks would be dependent upon plant operations. However, the cooling tower desilting basin and Unit 1 and 2 service water post cooling tanks would be possibilities.

D. Contribution of Water Table and Confined Aquifer Flow

The area to be dewatered would be approximately 4,500,000 square feet with a volume of 135,000,000 cubic feet if totally saturated. The water table has a maximum head of 6.2 and a low point of 1 foot. If the assumed specific yield of the saturated soil is 0.15 and, for conservative analysis, a maximum head of 6.2 is used, 4,185,000 cubic feet of water would be handled. The Gettysburg Formation wi act as a leaky barrier in the direction of strike and in areas of intense jointing. The recharge thru the slurry wall would be neglible (<0.003 cfs). The leakage from the Gettysburg Formation would be anticipated to be small but not definable without further site investigations.

VI. MONITORING

A. Present System

At present there are no wells on TMI and no groundwater is being used for plant operations (FSAR section 2.4.13.1). The site investigation borings were sealed following the construction phase. The Final Environmental Statement, in section 2.4.13.4 states:

> "Radioactive liquid waste from Unit 2 can only be discharged to the Susquehanna River; no liquid waste is discharged directly to any groundwater supplies. Since the Susquehanna River is then the only source of radioactive liquids and since the hydraulic gradient on the island and on the shore slopes to the river, radioactivity from the river does not contaminate groundwater supplies and therefore there is no need for monitoring or safeguards."

B. Proposed System During Plant Emergency

A proposed monitoring system of wells would only be necessary during a core meltdown or potential releases from decontamination procedures. These wells would monitor both the unconsolidated materials and the bedrock in an area to the south and west of the reactor building. At present a gravel pack well or trench drain with would be sufficient to monitor any possible contamination. The monitoring could be accomplished in a rapid fashion or on a more permanent basis if contaminated effluent is to be stored in surface tanks for an extended period of time. The monitoring well or trench should be located adjacent and down gradient of the holding tanks and reactor building.

In the event of a core meltdown, a series of intermediate and deep monitoring wells located around the island would be advantageous. Again the emplacement and monitoring of these wells in the Gettysburg Formation should conform to safe operational procedures for the drilling crews and supervisory personnel.

Appendix

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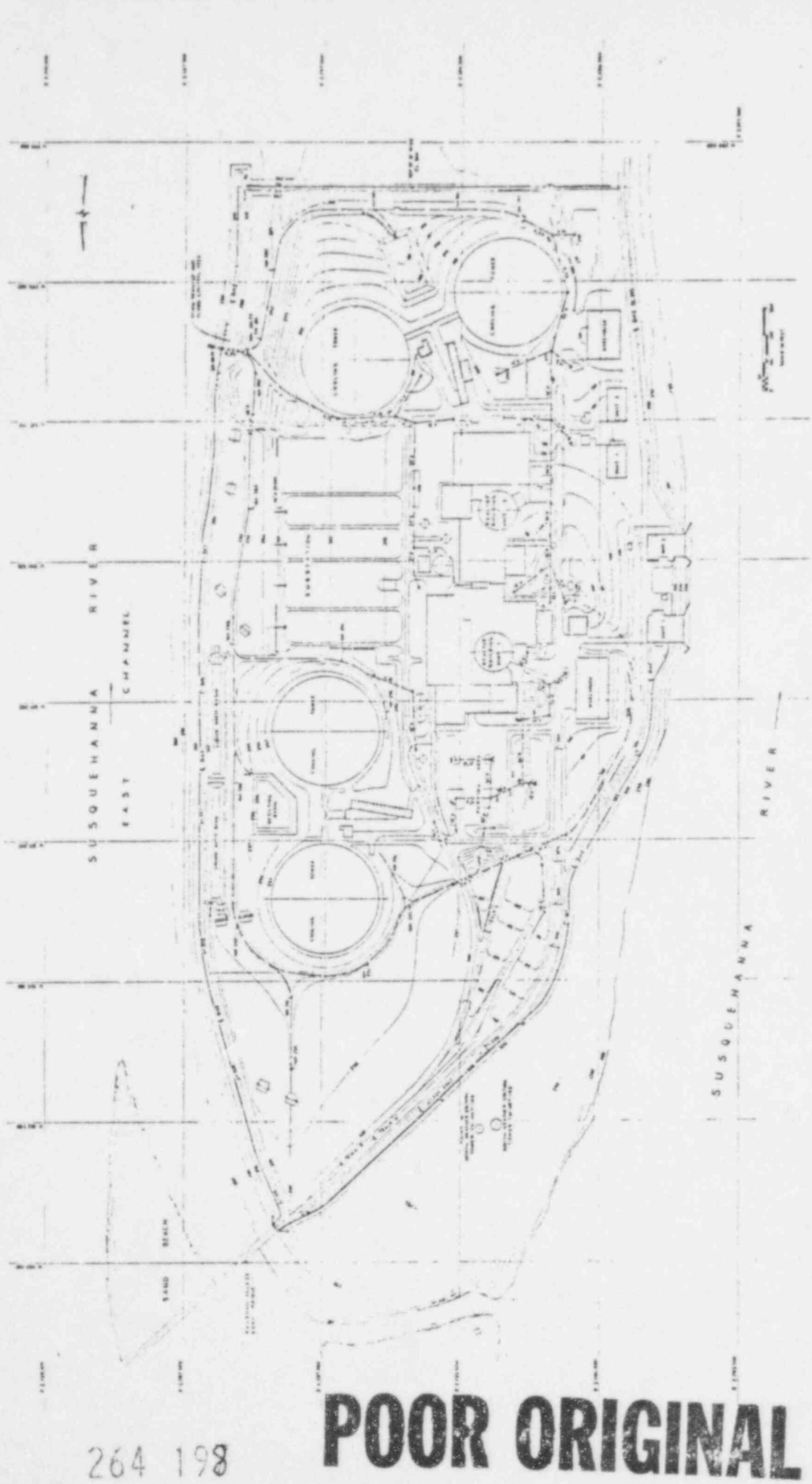
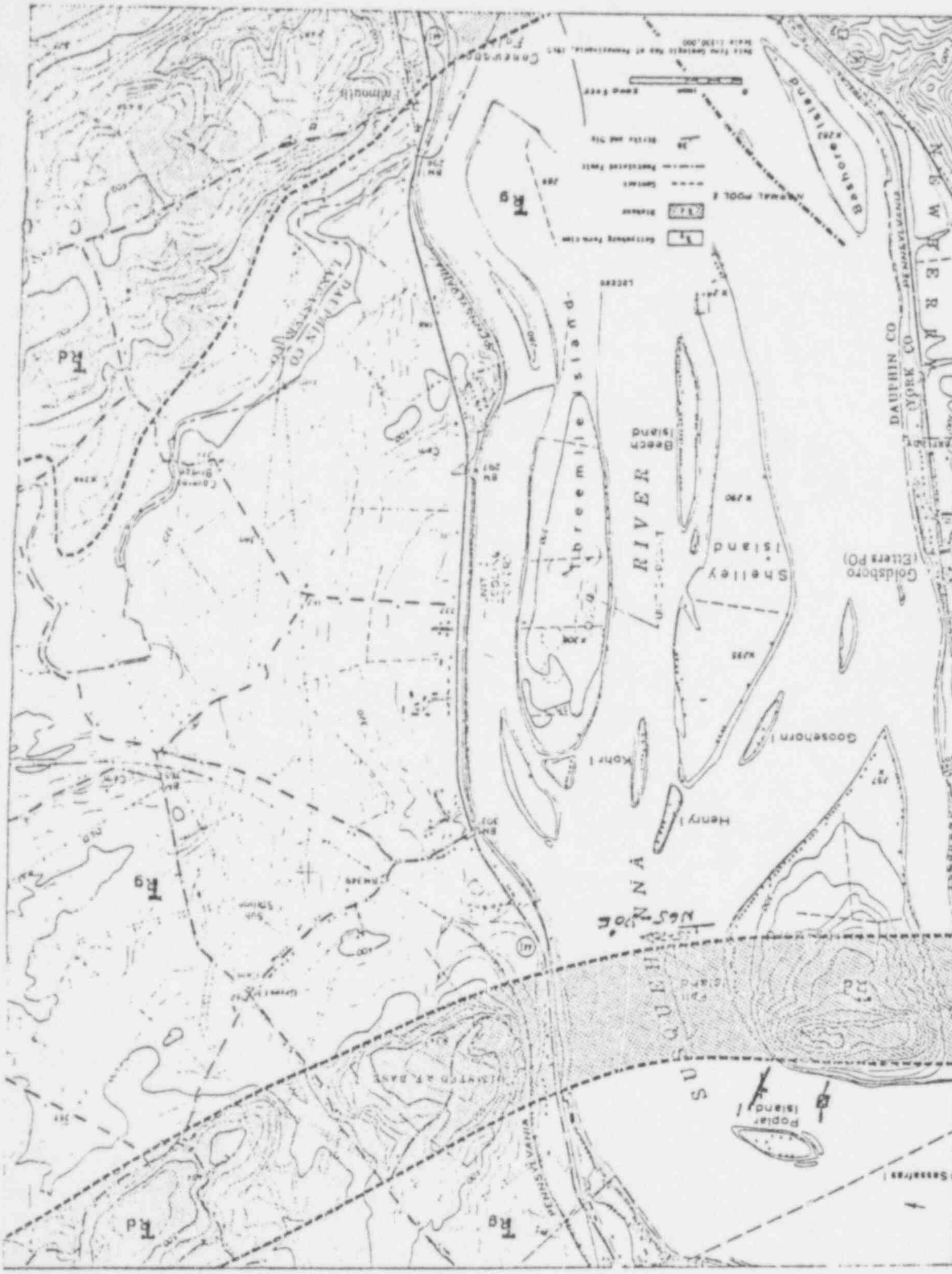


SITE TOPOGRAPHY, FACILITIES, AND DRAINAGE SYSTEM
THREE MILE ISLAND NUCLEAR STATION UNIT 2
FIGURE 2.4-1A

264 198

POOR ORIGINAL

GEOLOGIC MAP
THREE MILE ISLAND NUCLEAR STA
2.5-1



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POOR ORIGINAL

CONTOUR MAP – TOP OF ROCK
THREE MILE ISLAND NUCLEAR STATION U
FIGURE 2.5-2

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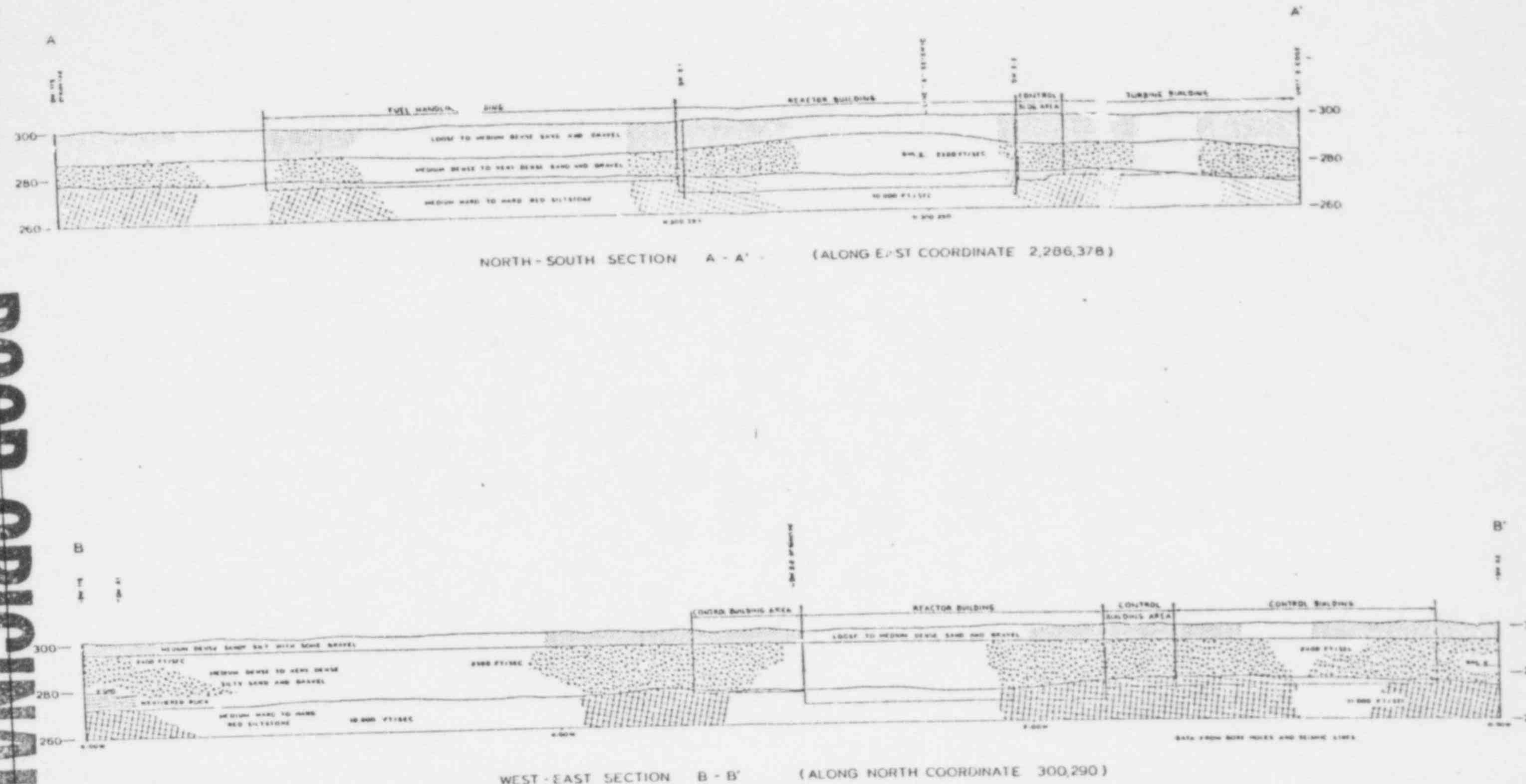

GEOLOGIC PROFILES
THREE MILE ISLAND NUCLEAR STATION UNIT 2

FIGURE 2.5-3

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POOR ORIGINAL