TECHNICAL EVALUATION REPORT

HYDROLOGICAL CONSIDERATIONS (SEP, II-3.A, B, B.1, 3.C)

JERSEY CENTRAL POWER AND LIGHT COMPANY
OYSTER CREEK NUCLEAR POWER PLANT

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

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1. INTRODUCTION

1.1 PURPOSE OF REVIEW

The purpose of this review is to evaluate the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP) Topics II-3.A (Hydrologic Description), II-3.B (Flooding Potential and Protection Requirements), II-3.B.1 (Capability of Operating Plants to Cope with Design Basis Flooding Conditions), and II-3.C (Safety-Related Water Supply - Ultimate Heat Sink) for the Oyster Creek Nuclear Generating Station. This review includes independent analyses by the Franklin Research Center (FRC) as needed to identify various hydrologic conditions. The NRC is reviewing other safety topics within the SEP and intends to coordinate an integrated assessment of plant safety after completion of the review of all applicable safety topics and design basis events (DBEs).

1.2 GENERIC BACKGROUND

The SEP was established to evaluate the safety of 11 of the older nuclear power plants. An important element of the program is the evaluation of the plants against current licensing criteria with respect to 137 selected topics, several of which relate to hydrologic assessments of the site.

In a letter dated January 14, 1981 [1], the NRC agreed to the SEP Owners Group's proposed redirection of the SEP, whereby each licensee would submit evaluations of 60% of the SEP topics in time for a review by the NRC staff to be completed by June 1981. Evaluations of the topics not selected by each licensee were the NRC's responsibility.

1.3 PLANT-SPECIFIC BACKGROUND

This technical evaluation report presents a review of the Licensee's evaluation of hydrologic influences at the Oyster Creek site. The assessment compares the Oyster Creek plant against the criteria currently used by the regulatory staff for licensing new facilities. The Licensee, Jersey Central Power and Light Company, submitted its first evaluation of SEP Topics II-3.A, II-3.B, II-3.B.1, and II-3.C on May 7, 1981 [2] and subsequently responded to further NRC questions in February 1982 [3].

2. REVIEW CRITERIA

The reference criteria used for all the hydrology topics were based on the Code of Federal Regulations, Volume 10, Section 50 (10CFR50), Appendix A, General Design Criteria, Overall Requirements, Criterion 2, entitled "Design Bases for Protection Against Natural Phenomena." Specific topic review criteria were taken from the following documents:

Standard Review Plan (SRP) [4]

- 2.4.1 Hydrologic Description
- 2.4.2 Floods
- 2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers
- 2.4.4 Potential Dam Failures
- 2.4.5 Probable Maximum Surge and Seiche Flooding
- 2.4.6 Probable Maximum Tsunami Flooding
- 2.4.7 Ice Effects
- 2.4.8 Cooling Water Canals and Reservoirs
- 2.4.9 Channel Diversions
- 2.4.10 Flooding Potential Requirements
- 2.4.11 Low Water Considerations
- 2.4.13 Groundwater

Regulatory Guides

- 1.27 Ultimate Heat Sink for Nuclear Power Plants [5]
- 1.59 Design Basis Floods for Nuclear Power Plants [6]
- 1.102 Flood Protection for Nuclear Power Plants [7]

American National Standards Institute (ANSI) N170-1976 [8]

Standards for Determining Design Basis Flooding at Power Reactor Sites.

3. TECHNICAL EVALUATION

3.1 HYDROLOGIC DESCRIPTION (SEP TOPIC II-3.A)

3.1.1 Topic Background

This report is a review of the Licensee's evaluation of Systematic Evaluation Program (SEP) Topic II-3.A, Hydrologic Description, for the Oyster Creek Nuclear Generating Station [2, 3]. The purpose of this review is to verify that the site hydrologic environment is adequately described and that plant hydrologic design bases are identified where available.

The conclusions presented in this section were derived from several sources, including NRC docketed information, NRC staff files, a plant site visit [9], and a Burns and Roe, Inc. report [3].

3.1.2 Topic Review Criteria

The review criteria used for this section are identified in American National Standards Institute N170-1976 [8] and Standard Review Plan Section 2.4.1 - Hydrologic Description [4].

3.1.3 Evaluation

3.1.3.1 Site and Facilities

The Oyster Creek Nuclear Power Plant is located in Ocean County, New Jersey, on the east shore of Barnegat Bay and about 2 miles inland (see Figure 1). The plant site covers approximately 800 acres. The plant structures were built on an island created by the intake canal to the north and west, the discharge canal to the south and west, and Barnegat Bay to the east (see Figure 2). A dike due east of the reactor and turbine buildings separates the intake and discharge canals and provides ready access to the rest of the site from the island. The intake canal extends from Barnegat Bay westward. It passes to the north of the Oyster Creek plant buildings, where it curves south to the intake structure as shown in Figure 2. It ends at the north side of the dike, on the south side of which the discharge canal originates. The discharge canal curves 90° to flow due east toward Barnegat Bay. The intake canal has a bottom width of 140 feet

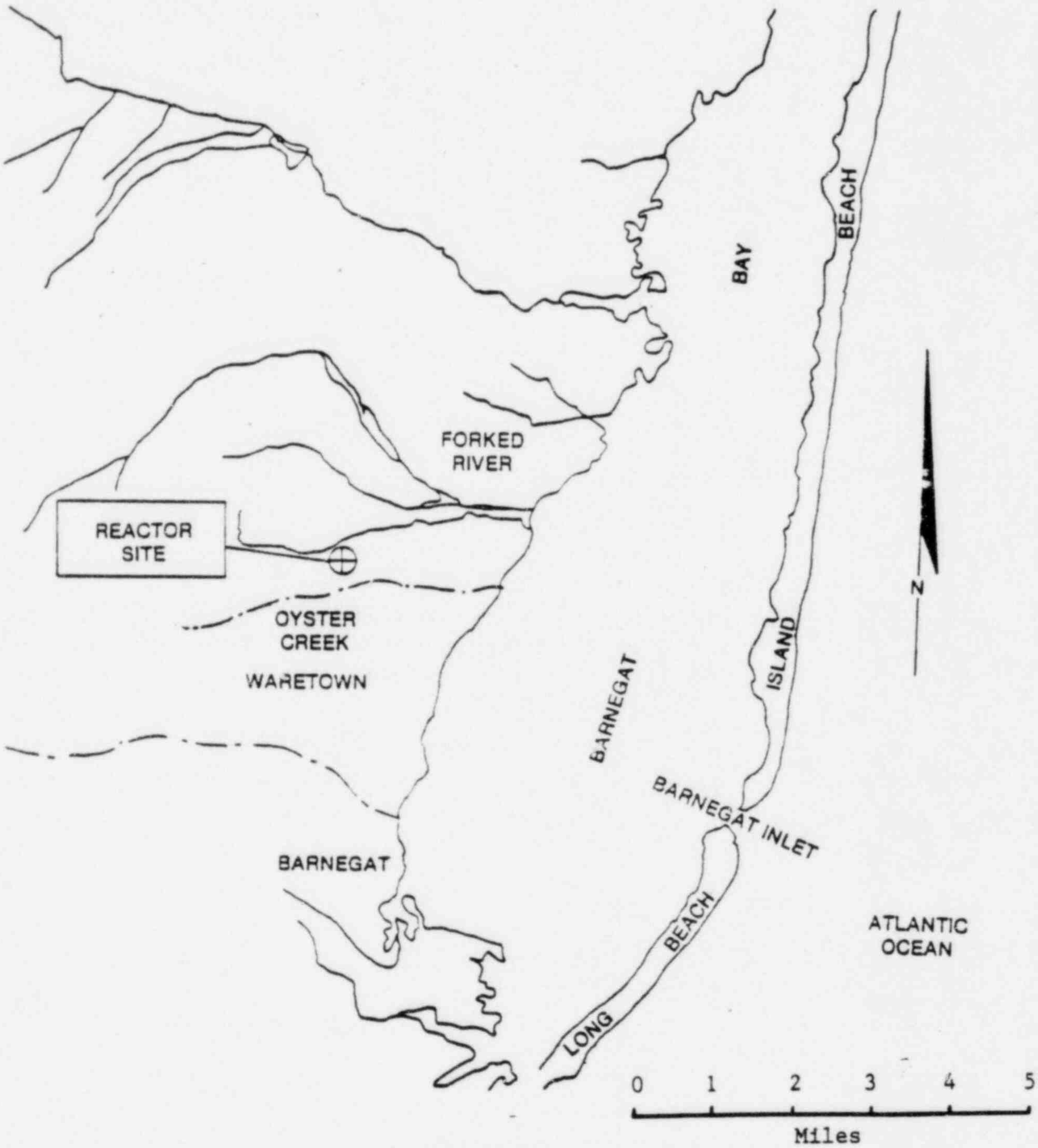

Figure 1. Site Location

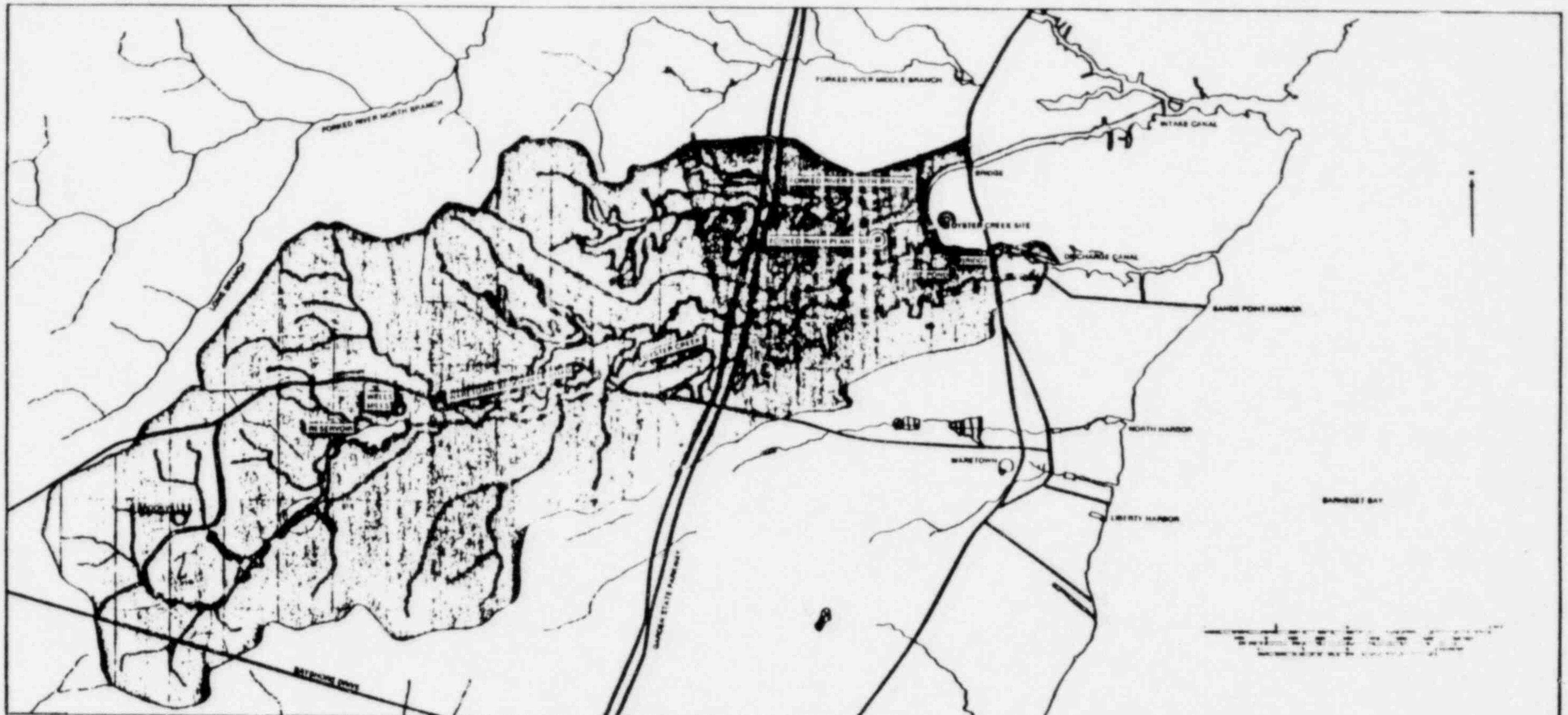

Figure 2. Plant Location Showing Intake and Discharge Canals

and the discharge canal is 100 feet wide at bottom [2]. Both canals have trapezoidal cross sections with side slopes 2 vertical to 3 horizontal. Bottom elevation is -10 feet msl [3].

3.1.3.2 Streams

On the south of the plant site, Oyster Creek flows east to Barnegat Bay. Its drainage basin is 12.4 square miles and consists mostly of pine barrens. It is dammed by a low-head earthen dam known as the Wells Mills Dam, with a timber spillway and shallow reservoir about 4 miles upstream from the plant site. Another low-head timber dam on the site forms a pond with a 4-acre surface area. It is used to store fire water for use at the plant. Oyster Creek joins the discharge canal approximately 700 feet west of the Route 9 bridge. To the north of the site is South Branch Forked River, with a watershed area of 2.7 square miles, also flowing west to east in pine barrens land. It is not dammed and empties into the intake canal just upstream of the railroad and Highway 9 bridges crossing the intake canal [3]. The South Branch Forked River discharge flows through two structures before reaching the canal. One is a 12-inch diameter steel pipe, and the other is a water passage under the Forked River Nuclear Power plant site access road [3].

Barnegat Bay is a relatively shallow body of water extending in a north-south direction parallel to the New Jersey coastline. It is separated from the Atlantic Ocean by Long Beach Island and Island Beach Peninsula, which are divided from each other by the narrow Barnegat Inlet. The bay itself is approximately 20 miles long, from 1 to 5 miles wide, and varies in depth between 1 and 10 feet. It is part of the intracoastal waterway, adjacent to Little Egg Harbor on the south and Silver Bay on the north. On the oceanfront at Barnegat Inlet, mean low water is -1.5 feet msl [10].

3.1.3.3 Groundwater

Test borings at the Oyster Creek site showed groundwater at less than 10 feet below grade. The water table slopes gradually down to Barnegat Bay in the east. Soil is sandy, with clay silt layers at 17 and 100 feet below plant grade. These layers act as aquicludes; the lower one confines an aquifer under enough pressure to lift the water 89 feet to 12 feet mean sea level (msl). The plant foundation penetrates lower than the upper clay silt layer. The drinking water supply for the plant is a well that draws water from the lower of these two aquifers [3]; most wells in the area are 60 feet deep or deeper.

3.1.3.4 Design Bases

Hurricane

The high water level used in designing the Oyster Creek Nuclear Power Plant was 4.5 feet msl [11]. This level is based on recorded flood marks at the site from a storm which struck New Jersey in 1962 and is the highest historical water level at the site. The deck of the intake structure is at 6.0 feet msl, 1.5 feet above the design basis storm water level. All other safety-related structures are located at 23 feet msl, with doorsills at elevation 23 feet 6 inches msl [3].

Low Water Level

There is no design basis low water level for the Oyster Creek plant. However, the extreme low water level to be expected on the west shore of Barnegat Bay was calculated by the Licensee as -3.4 feet msl. Hydraulic losses in the intake canal are assumed to be 1 foot, resulting in low water elevation of -4.4 feet msl at the intake structure [12].

Streams and Rivers

Flooding from Oyster Creek and South Branch Forked River was not considered in the design of the Oyster Creek plant. Local rainfall was assumed to runoff into the intake and discharge canals and east toward Barnegat Bay. To facilitate run off, the plant island is graded away from the center in all four directions and a storm sewer system was installed [3].

Groundwater

The plant structures (see Figure 3) were designed to withstand the hydrostatic and uplift pressures of groundwater to the following levels:

Structure	Design Basis Groundwater Level (feet msl)
Reactor building	15.0
Turbine building	15.0
Old and new radwaste buildings	No hydrostatic loads applied
Intake structure foundation	3.0
Pipe tunnels connecting old and new radwaste buildings	22.0
New radwaste building, offgas building, boiler house, and others with foundation mat at 23 feet msl	No hydrostatic pressure

Roof Rainfall Loading

The roofs of the reactor and turbine buildings were designed to support a live loading of 30 psf. Parapet heights around the rooftops are as follows:

Building	Parapet Height Above Crown	Parapet Height Above Low Points Along Edge
Reactor	8 in	2 ft 2 in
Turbine	8 in	1 ft 11 in
Office (not safety-related)	—	8 in (no parapet)
Mechanical (not safety-related)	—	8 in (no parapet)

Roof drains are provided to decrease ponding [3]. The design bases are summarized in Table 1.

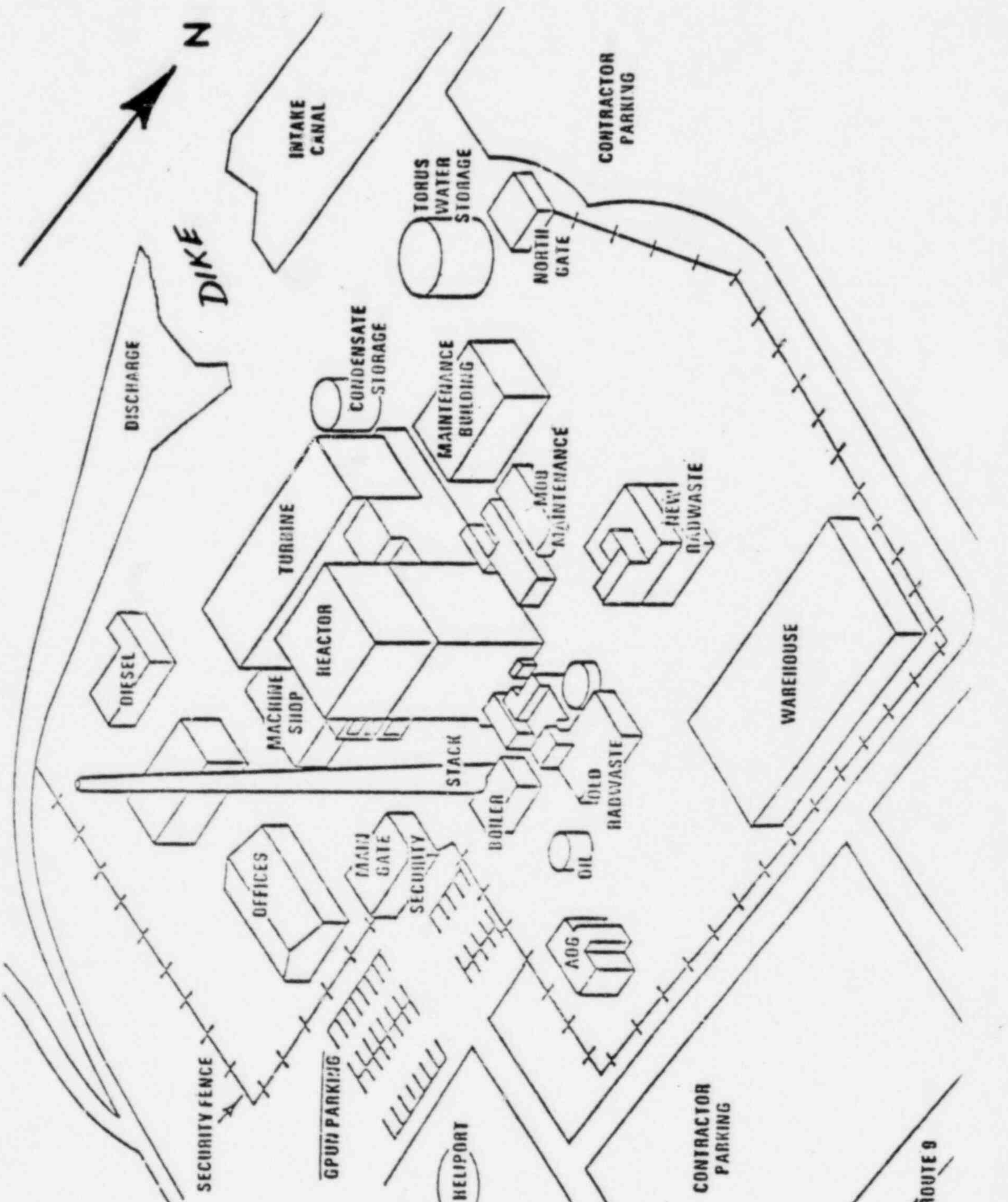

Figure 3. Site Layout

Table 1. Design Bases

Safety-Related Structure	Design Basis: Original	Design Basis: Present Day
High Water		
Intake	4.5 ft msl	6.0 ft msl
All other structures	4.5 ft msl	23.5 ft msl
Low Water		
Intake	none	none
All other	none	none
Roof Flooding		
All structures	30 psf	30 psf
Groundwater		
Reactor	15 ft msl	15 ft msl
Turbine	15 ft msl	15 ft msl
Intake structure	3 ft msl	3 ft msl
Old and new radwaste buildings	no hydrostatic loads	
Offgas building	no hydrostatic loads	

3.1.4 Conclusion

Local surface water users other than the Oyster Creek Nuclear Generating Station (if any) should be itemized. On all other points, the hydrologic environment is adequately described by the Licensee.

3.2 FLOODING POTENTIAL AND PROTECTION REQUIREMENTS (SEP TOPIC II-3.B)

3.2.1 Topic Background

The purpose of this topic is to identify the design basis flood level for the plant and site, under current licensing criteria, resulting from all potential flood sources external to the plant and site. The topic evaluates differences between the levels or values used for original design and construction and those derived under current licensing criteria. This evaluation includes the flood effects on safety-related structures, systems, and equipment. This evaluation also presents existing or proposed flood protection measures such as revetments, flood walls or doors, and emergency or administrative procedures.

The NRC's Regulatory Requirements Review Committee has specifically stated that all operating reactors must be evaluated for compliance with Regulatory Guides 1.59 [6] and 1.102 [7], including plants that began operation before those guides were issued. The guides are used to determine whether the facility design complies with current criteria or has some equivalent alternatives acceptable to the staff. The acceptability or nonacceptability of any deviations identified in this evaluation and the need for further action will be judged during the integrated assessment for this facility.

The conclusions presented were developed using several sources of information, including NRC docketed information, NRC staff files, United States Geological Survey mapping, and National Weather Service reports.

3.2.2 Topic Review Criteria

Criteria for the review of flooding potential and protection requirements were taken from the following sources:

Standard Review Plan (SRP) Sections

2.4.2 Floods

2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers

2.4.4 Potential Dam Failures

2.4.5 Probable Maximum Surge and Seiche Flooding

2.4.6 Probable Maximum Tsunami Flooding

2.4.7 Ice Effects

2.4.10 Flooding Protection Requirements

2.4.12 Groundwater

NRC Regulatory Guides

1.59 Design Basis Floods for Nuclear Power Plants

1.102 Flood Protection for Nuclear Power Plants

1.135 Normal Water Level and Discharge at Nuclear Power Plants

American National Standards Institute N170-1976

Standards for Determining Design Basis Flooding at Power Reactor Sites.

3.2.3 Evaluation

This section reviews flooding potential at the Oyster Creek site by several hydrologic events, and the requirements for protection against them. Hydrologic events investigated in the following order are:

1. local plant flooding
2. flooding on rivers and streams
3. hurricane storm surge
4. rooftop ponding
5. groundwater.

3.2.3.1 Flood History

The highest water level ever recorded at the plant site was 4.5 ft msl during a severe storm in 1962 [3].

The Licensee has calculated that the extreme low water level to be expected at the intake structure is -4.4 ft msl [12].

A streamflow gaging station has been maintained on Oyster Creek since 1956. It is located upstream from the plant site, and extrapolation of the records to the confluence of Oyster Creek and the discharge canal was performed by the Licensee. The resulting maximum flow is 474 cfs, from July 4, 1978 [3]. South Branch Forked River is ungaged, and there is no record of any floods on its watershed.

3.2.3.2 Extreme Event Definitions

For reference purposes, the following extreme events are defined.

Probable Maximum Precipitation Definition

The local probable maximum precipitation (PMP) according to present NRC criteria at the Oyster Creek plant for a 24-hour duration is 31.88 inches. The 6-hour PMP according to present NRC criteria is 27 inches [13], and could occur in hourly increments of 13.23, 4.05, 3.24, 2.43, 2.16, and 1.89 inches, in any order [14]. Use of greater rainfall rates in evaluation of storm runoff adequancy is an acceptable procedure such that the results are more conservative than present NRC criteria. This precipitation distribution is used to evaluate the adequacy of site drainage, roof top loading, and stream stormwater runoff.

Probable Maximum Hurricane Definition

The NRC requires all new nuclear power plants to withstand the probable maximum hurricane (PMH) high stillwater level plus windwaves. Structures, systems, and components necessary for cold shutdown must be equipped with hardened flood protection. Regulatory Guide 1.59 provides an estimate of 23.8 feet above mean low water (mlw) as the probable maximum surge still water level at the open coastline [6]. This is the equivalent of 22.3 feet msl. A lower value may be acceptable to the NRC if it is computed by the methods contained in ANSI N170-1976 [8].

3.2.3.3 Evaluation of Hydrologic Events

Local Plant Flooding

Current NRC criteria require that all safety-related structures and equipment be protected against flooding from local PMP [6]. In evaluating flooding potential, no credit may be taken for storm drains, since they may be blocked almost immediately by debris carried by storm water.

The Licensee's submittal indicates that the plant island is divided into three drainage basins. The area with the greatest potential of local flooding is the 5.2-acre area at the north, and includes the storeroom, mobile offices, old and new radwaste buildings, office building, boiler house, and part of the reactor building. Existing storm drains functioning at full capacity are assumed to remove 6 cfs of runoff, leaving a peak overland flow of 60 cfs. Ponding results to elevation 23 feet 5 inches msl (5 inches deep); the lowest exterior opening is 23 feet 6 inches msl [3].

The Licensee's calculations were not presented for review and therefore could not be evaluated. However, a site visit [9] and inspection of topographic maps [15] show that natural drainage exists for the plant island. The only exception is an area around the southwest door of the offgas building (labeled AOG on Figure 3), where plant yard elevation rises in every direction. In a heavy rainfall, storm water would accumulate in this low spot. There is a 6-inch sill on this door, but its top is below the lowest drainage outlet. There is no storm drain in this small watershed [9]. Unless the Licensee can demonstrate, using post-construction topographic maps of small contour interval, that runoff sufficient to overflow the doorsill will not accumulate, this area of the plant will be considered not in compliance with current NRC design criteria. It is recommended here that the landscape be modified to provide a swale as an outlet for storm water.

Rivers and Streams and Dam Failure Flooding

The Licensee has determined, and independent analysis confirms, that flooding on Oyster Creek or South Branch Forked River will not flood the Oyster Creek plant site [3].

The quantity of the flow from PMP on Oyster Creek would be 38,700 cfs, or 40,700 cfs if Wells Mills Dam failed. The fire protection pond stores such a small quantity of water that failure of its dam would not significantly affect water levels. Oyster Creek empties into the plant discharge canal, which passes under a U.S. Highway 9 bridge. At the bridge, the cross section is restricted, and the highest flood levels would be produced here. An elevation of 11.8 ft msl (or 12.2 ft msl with the failure of Wells Mills Dam) would result at the bridge and back up the discharge canal. The dike west of the reactor building between the intake and discharge canals would protect the intake canal and the intake structure from these water levels. Some water would flow through the dilution pump casing, driven by water pressure head, from the discharge to the intake canal. Flow rates could reach 5600 cfs (or 6000 cfs with the failure of Wells Mills Dam) [3].

The South Branch Forked River would produce 8900 cfs during PMP. Its flow is restricted upstream of its confluence with the intake canal by a 12-inch-diameter steel pipe and the Forked River site access road bridge. The resulting water level upstream would be 9.2 feet msl. Higher inflows into the intake canal would produce a water level of 1.8 feet msl. The addition of flow from the discharge canal via the dilution pump casing (in the event of simultaneous PMP on Oyster Creek and the South Branch Forked River) would increase the total flow in the intake canal to 14,100 cfs, or 14,500 cfs if Wells Mills Dam failed. The canal would not be choked by the Highway 9 bridge, and resulting water levels at the intake would be 3.5 feet msl, or 3.7 feet msl with the failure of Wells Mills Dam [3]. This water elevation would not interfere with normal plant operation since the intake structure limiting elevation is 6 ft msl.

A complete failure of the dike between the intake and discharge canal during the PMF event could add water to the intake canal sufficient to elevate the water to approximately 5 ft msl. Sheet pile reinforces the lower portion of this dike which is topped with compacted soil fill. The stability of this embankment should be evaluated under SEP Topic II-4.D.

From a hydrologic standpoint, assuming the dike remains in place, the dike will be overtopped for a short duration (less than 2 hours) during the PMF discharge, and water would be ponded behind the dike on the discharge side for approximately 6 hours.

Further, assuming dike failure (and assuming adequate remote sensing of water elevation is provided to the control room operator), the rapid rise of water in the intake canal would initiate an emergency shutdown similar to Oyster Creek Emergency Procedure No. 520.

An independent study of PMF on Oyster Creek and South Branch Forked River was performed for this report to confirm the Licensee's definition of PMF elevation and discharge. The methods used are outlined in Regulatory Guide 1.59 [6], Hydrometeorological Report Number 51 [16], the Bureau of Reclamation's Design of Small Dams [14], and the Soil Conservation Service's Hydrology [17]. The results are as follows:

Method	Oyster Creek Discharge (cfs)	South Branch Forked River Discharge (cfs)
Regulatory Guide 1.59	49,000	23,500
Bureau of Reclamation	29,500	--
HR 51 and Soil Conservation Service	48,028	7967
Licensee	40,700*	8900

The analyses performed according to Regulatory Guide 1.59 may yield an unsupported conclusion since the evaluation involved an extrapolation of areas less than 100 square miles. Regardless, the present evaluation indicates that both channels are capable of carrying the PMF discharge identified in Regulatory Guide 1.59, as well as that identified by the Licensee [3] without jeopardizing safety-related structures at plant grade. However, the diesel-

*The Licensee adds an additional 2000 cfs to the flood as a result of the Wells Mills Dam failure.

driven fire pumps will be inundated by the PMF of Osyter Creek. An evaluation of SEP Topic II-4.D, as applied to the dike between the intake and discharge canals, may indicate that the PMF of Oyster Creek could flood the intake structure.

Hurricane Storm Surge

The Licensee has concluded that the PMH storm surge still water level at the site is 22 feet msl [10, 18 through 23], 1.5 feet below the level of protection of all safety-related structures except the intake structure, and 1.0 foot below plant grade. Less than 1 foot of wave runup would occur. Independent review confirms that this PMH surge elevation fulfills the guidelines specified in ANSI N170-1976, and that appropriate input assumptions have been used throughout the analysis. The intake structure, with deck elevation at 6.0 feet msl, would be submerged by a PMH, necessitating shutdown of the plant. This scenario is detailed in Procedure 520 [24], which is reviewed under SEP Topic II-3.B.1, Capability of Operating Plants to Cope with Design Basis Flooding Conditions.

Wave forces on the intake structure will be minimal due to refraction around the plant island. Hydrostatic loads to elevation 22 ft msl should be considered in evaluation of loading conditions and structural adequacy of the intake structure under SEP Topic III-3.A, Effects of High Water Level on Structures.

Rooftop Ponding

The roofs of safety-related structures should be able to withstand local PMP without failing, according to current NRC criteria [6]. Roof drains must be assumed to be completely blocked unless adequate assurance can be provided that confirms their full operability.

The structural design basis for loading on roofs of Oyster Creek safety-related structures is 30 psf [3]. This is the equivalent of 5.76 inches of ponded water.

The roofs of safety-related structures at the Oyster Creek plant are surrounded by parapets on all sides, which would create some ponding. Parapet heights provided by the Licensee for four of the structures are as follows:

Building	Parapet Height Above High Points	Low Points
Reactor	8 in	2 ft 2 in
Turbine	8 in	1 ft 11 in
Office	—	8 in (no parapet)
Mechanical Equipment Room	--	8 in (no parapet)

The meaning of the information provided in Reference 3 for the office building and the mechanical equipment room is unclear. Therefore, it is assumed that the structural configuration allows 8 inches of water to be ponded over the low points of these roofs. Parapet heights are not specified for the offgas building, the old or new radwaste buildings, or the emergency diesel generator building, all of which either are safety-related or would cause unacceptable consequences if flooded [9].

With reactor building roof drains 100% blocked, 6 hours of PMP would fill the volume confined by the parapets. Water would be ponded to a depth of 8 inches over the crown, and 26 inches of water would cover the low points. These depths of water result in loads of 41.7 psf and 135.4 psf, respectively. The lower of these loads is 11.7 psf, or 39%, above the design basis loading. The average load, assuming a linear variation, is 88.6 psf. The highest single hour of PMP would produce 12.23 inches of rainfall, equivalent to an average loading of 63.54 psf. According to the information available, the roof of the reactor building does not meet current NRC criteria. Compliance could be achieved by providing scuppers in the parapets along the low edges of the roof, or by removing sections of those parapets.

The Licensee states that, with reactor building roof drains fully functional, the ponding from 6-hour PMP would be 10 inches (52.1 psf) in the lowest parts of the roof, and the average loading would be approximately 20 psf [3]. These values cannot be confirmed by independent review, due to a lack of information from the Licensee. Loading above 30 psf in any part of the roof exceeds the design basis, despite lower average loading. Therefore, even with roof drains fully functional the roof of the reactor building cannot withstand the PMP.

The rainfall with 6-hour duration and 100-year frequency at the Oyster Creek plant is 6 inches [25]. With roof drains fully blocked, this rainfall would produce ponding, and the average loading would exceed the design basis. Clearly, the design basis would be surpassed in the low points in less than 6 hours. The roofs of safety-related structures at Oyster Creek cannot withstand the 100-year-frequency rainfall.

The new radwaste building has parapet walls around the roof, and the roof surface is sloped down toward the drains in the center, unlike the reactor and turbine building roofs [9]. Ponding in the center of the new radwaste building might not be adequately reduced by removal of sections of the parapets. One section of the roof is raised above the remainder of the roof level (see Figure 3) and is drained by downspouts which empty onto the lower rooftop [9]. This arrangement adds to ponding and associated loading on the rooftop. Other safety-related buildings should be investigated for similar conditions, which must be considered in predicting rooftop ponding.

The roofs of Oyster Creek safety-related structures do not conform with current NRC criteria. With roof drains fully blocked, the 100-year-frequency rainfall with 6-hour duration exceeds the design basis roof loading. The roofs of all plant structures whose flooding could cause release of radiation (old and new radwaste buildings and off gas building) were not described in the Licensee's submittal and should be studied. Further, structural modifications are recommended to achieve compliance with current NRC criteria.

Groundwater

According to current NRC criteria, all safety-related structures must be designed to withstand hydrostatic and uplift pressures produced by groundwater.

A conservative high water table elevation should be chosen as the design basis [4]. Groundwater monitoring over a period which includes seasonal fluctuations and intervals of low rainfall or low surface water levels may provide reasonable assurance that a conservative design basis has been chosen.

The Licensee's submittal [3] mentions records of groundwater level at 13 and 18 feet msl. The water table is consequently assumed to be less than 10 feet below grade. An estimate is provided of groundwater elevations during PMH, which shows that the maximum height would be 22 feet msl.

Since the duration and exact location of well readings are not specified, nor were estimates made of water table rise due to recharge from local precipitation, groundwater should be assumed to rise to plant grade under some conditions, and all structures should be protected against hydrostatic and uplift pressures to grade elevation, which can be referred to as the probable maximum groundwater elevation. The short duration of high groundwater levels does not affect the conclusion that structures should be designed to withstand the resulting short duration hydrostatic loads.

In addition to being protected from the probable maximum groundwater elevation (plant grade elevation 23 ft), structures related to safety must be capable of withstanding a combination of normal high groundwater with an appropriate seismic load. A normal high groundwater elevation for the Oyster Creek site to be used in evaluating this combined event should be 18 ft msl. This level was deemed appropriate by the Licensee according to page 16 of Reference 3.

Plant grade elevation is above the original design basis groundwater elevation for the reactor and turbine buildings, the intake structure foundation, and pipe tunnels connecting the old and new radwaste buildings. Design level is not specified for the emergency diesel generator building (see Section 3.1.3 for design bases). Therefore, the adequacy of the Oyster Creek plant safety-related structures to withstand groundwater level at plant grade cannot be certified under this topic. SEP Topic III-3.A, Effects of High Water Levels on Safety Related Structures, should address this subject.

3.2.4 Conclusion

3.2.4.1 Local Runoff During PMP

The Licensee's submittal states that an analysis shows that local runoff during PMP will not flood safety-related structures if storm drains are fully functioning. Inspection of site topography shows that acceptable overland runoff should occur even with storm drains blocked, except in a small area at the southwest corner of the off gas building, where ponding and flooding would take place. Remedial action consists of providing higher curbs, or grade modification which would enable runoff to discharge to the canal system.

3.2.4.2 PMF of Streams and Rivers

Flooding on Oyster Creek and South Branch Forked River during PMP will not affect normal plant operation. Neither the intake structure, at elevation 6.0 feet msl, nor the plant buildings, at 23 feet msl, will be inundated.

3.2.4.3 Probable Maximum Hurricane

The PMH surge level computed by the Licensee complies with current NRC standards. During a PMH event, stillwater level plus wave runup would not reach plant grade, but safety-related structures such as the intake structure and the diesel fire pumps would be inundated. Procedure 520 [24] is designed to enable the plant to shut down safely during high water levels, and is reviewed under SEP Topic II-3.B.1, Capability of Operating Plants to Cope with Design Basis Flood Conditions.

3.2.4.4 Roof Rainfall Loading

The roofs of safety-related structures are not designed to support the amount of water which can be ponded behind parapets. With drains fully blocked, the reactor and turbine building design loads would be exceeded in less than 6 hours of PMP. Lack of information about other roofs and about roof drains makes it impossible to confirm the Licensee's statement that the design basis loading will not be exceeded by the loading from PMP averaged over the roof if drains are completely functioning. The fact that average loading is below the allowable level does not prove the acceptability of a loading configuration in which some areas of the roof are loaded beyond the design basis. The roofs do not fulfill current NRC criteria.

Roofs need to be designed to carry water ponded to the top of the parapet, or the following remedial actions could be taken:

a. for these roofs which fail under PMP loads, parapet walls can be breached by scuppers, or removal of wall sections.

b. for those roofs nearly protected to the PMP load condition, an appropriate inservice inspection program which verifies continuous drain operation could be developed so that credit can be taken for drainage by the roof drain system.

3.2.4.5 Groundwater

Groundwater records which define a conservative design basis groundwater level were not provided by the Licensee. Therefore, an independent evaluation concludes that groundwater must be assumed to rise to plant grade. During the PMH, surface water rises to plant grade, and it is likely that groundwater will rise to this elevation within a short time. This elevation is above the design basis for some safety-related structures. Normal high groundwater elevation to be used in combination with an appropriate seismic load should be 18 ft msl. Further evaluation under SEP Topic III-3.A, Effects of High Water Level on Structures, is recommended.

3.3 CAPABILITY OF OPERATING PLANTS TO COPE WITH DESIGN BASIS FLOOD CONDITIONS (SEP TOPIC II-3.B.1)

3.3.1 Topic Background

Protection against postulated floods can be accomplished by implementing emergency procedures and technical specifications. This section evaluates the adequacy of the Oyster Creek plant emergency procedures for flood control which were intended to preclude flooding of safety-related equipment necessary for maintaining the safe operation and cooldown of the reactor system.

The evaluation uses information obtained during an Oyster Creek plant site visit, NRC docketed information, and the PMF hydrograph developed in Section 3.2 of this report.

3.3.2 Topic Review Criteria

The following references were used as review criteria:

ANSI N170-1976

Regulatory Guides 1.59 and 1.102

Standard Review Plan, Sections 2.4.3, 2.4.4, 2.4.5, 2.4.7, 2.4.8, 2.4.10, and 2.4.14.

3.3.3 Evaluation

The Licensee's submittal [3] has addressed the plant's capability to cope with the following hydrologic phenomena:

- o PMF from local streams
- o Local site runoff from PMP
- o Flooding from PMH surge
- o Groundwater fluctuations.

Evaluations and conclusions regarding the technical adequacy of the Licensee's statements are provided within the text of each of these subtopics.

3.3.3.1 Probable Maximum Flood (PMF)

The Licensee states that the PMF of both Oyster Creek and South Branch Forked River does not affect safety-related systems or components. Thus, no emergency procedures are required to deal with consequences of the probable maximum flood phenomenon due to a probable maximum precipitation phenomenon. Review within this TER confirms the Licensee's evaluation.

Should a review of SEP Topic II-4.D indicate that a failure of the dike separating the intake and discharge canals is a credible event, further evaluation of the level of protection against a PMF discharge of Oyster Creek should ensue.

3.3.3.2 Local Site Runoff from PMP

The Licensee has indicated that significant ponding will not occur during a PMP occurrence at the site and that no emergency procedures are necessary.

As described in previous sections of this report, a PMP event causes local ponding in selected areas which may enter buildings housing safety-related equipment, presuming no credit is given for site drains. Although technical modifications, such as grade modification or curb construction, should be made to the site's PMP protection features, no emergency procedures are recommended.

The site, as presently graded, is capable of shedding runoff from a PMP to the intake and discharge canals, assuming no credit is given for the site drainage system.

3.3.3.3 Flooding from PMH Surge

The Licensee has indicated that a PMH event produces a flood level of elevation 22 ft msl where plant grade is elevation 23 feet msl. The circulating water pumps and emergency service water pumps will not operate when flood waters are over the pump motors. The diesel-driven fire pumps, located at grade level of 12 ft msl, will also be inoperable.

In order to cope with this situation, JCP&L has developed Oyster Creek Procedure No. 520, which prepares the plant for shutdown when the water level reaches elevation 4.5 feet msl.

It is noted that, at the time of the PMH surge, the service water pump motors (on deck elevation 6 feet msl), the circulation water pump motors (elevation 8 feet msl), and the fire pumps (pump house elevation 12 feet msl) will be submerged and inoperable. Further, the Licensee has identified the isolation condensers as the ultimate heat sink during the PMH event.

The following discussion focuses on an inadequacy of the Hurricane Emergency Procedure 520, specifically with regard to providing makeup water to the isolation condensers. The timing of the theoretical PMH surge is such that pump motors which supply water to the isolation condensers will be rendered inoperable in a relatively short time. Procedure 203.1, "Shutdown to Hot Standby," is initiated at water elevation 4.5 feet msl and followed within approximately 1 hour by Emergency Procedure 532 as rising surge levels reach elevation 6.0 feet msl. Less than 1 hour later, water will reach both the emergency service water (ESW) pump motors at 6.0 ft and circulating water pump motors at elevation 8 feet msl, and within another hour the diesel-driven fire pump will be submerged at an approximate elevation of 12 feet msl.* Consequently, within a span of approximately 3 hours, the available systems for providing makeup water to the isolation condensers will be overwhelmed by flood water. Therefore, a review of the iso-condenser supply is provided here.

Each isolation condenser shell contains a minimum water volume of 22,730 gallons by technical specification. With both condensers in operation, decay heat can be removed for approximately 1 hour and 40 minutes without replenishing the water supply. With only one condenser in operation, decay heat can be removed for approximately 45 minutes without the addition of makeup water. Consequently, in order to perform its decay heat removal function, it is essential that the capability to provide isolation condenser makeup be retained.

Isolation condenser makeup is accomplished by two means; either by using the condensate transfer pumps to provide water from the condensate storage tank or by makeup from the fire-protection system. For the purpose of this evaluation, the fire-protection method can not be relied upon because the diesel-driven fire-protection pumps will be submerged below the flood level and therefore will not be functional. In this condition, the condensate transfer pumps must be relied upon to provide makeup water to the isolation condensers.

The condensate transfer pumps are located above the flood level. There are two pumps available and there is no credible single active failure that can prevent makeup flow from reaching at least one of the isolation condensers when the transfer pumps are running. Although there are several manual valves

*It should be noted that no water level measuring device is available to plant operators to ascertain water level rise during the PMH.

in the common flow path from the transfer pumps which could be mispositioned so that makeup flow would be stopped, there should be sufficient time available to correct this type of problem before the isolation condensers lose their heat exchange capability. There is a problem, however, with regard to the power supplies to the pump motors in that a single active failure could cause the loss of power to both condensate transfer pumps.

Both condensate transfer pumps receive 460 Vac power from MCC 1B32, located in the chlorination building. MCC 1B32 is powered from the 1B3 substation through a step-down transformer from the 1B "vital" bus. Although the 1B bus can be powered from several sources, including the diesel generators, a single active failure of the breaker feeding the 1B3 substation from the step-down transformer (breaker 1B3M) would cause a loss of all power to MCC 1B32 and consequently the condensate transfer pumps would be without electrical power. Similarly, a failure of the 500 amp breaker connecting MCC 1B32 to substation 1B3 would also cause a loss of power to the transfer pumps.

A further consideration with regard to the reliability of the power supply to the condensate transfer pumps is that the power to MCC 1B32 is initially shed from the vital bus and must be manually reestablished once the diesel generator has reenergized the vital bus. As with the case of the manual valves discussed above, there appears to be sufficient time for the manual reenergizing of MCC 1B32 before the water inventory in the isolation condenser has been exhausted. However, it is not totally unrealistic to consider the possibility of the failure of a single breaker occurring at this time.

Since the fire-protection pumps are below the submergence level and the condensate transfer pumps can be rendered inoperative by a credible single active failure, the Licensee should consider alternative means or procedures to provide electrical power to the condensate transfer pumps or to provide an additional means to ensure makeup water to the isolation condensers.

3.3.3.4 Groundwater Fluctuations

The Licensee has commented on the adequacy of plant design features to protect against the occurrence of high groundwater. It is outside the scope of this technical review to assess the implications and effects of high groundwater on plant structures or equipment. This issue will be addressed under SEP Topic III-3.C, Effects of High Water Level on Structures. However, plant protection from groundwater to plant grade (elevation 21 ft msl) should be verified.

3.3.3.5 Technical Specifications

There are presently no plant technical specifications which incorporate flood emergency procedures at the Oyster Creek Nuclear Generating Station. It is recommended that a technical specification be prepared by the Licensee which limits operation of the plant when water levels in the intake and discharge canals exceed 4.5 ft msl. This specification will ensure that normal cooldown will be effected for as long as possible prior to emergency cooldown.

3.3.4 Conclusion

The present Oyster Creek Hurricane Emergency Procedure 520 does not provide adequate assurance that reactor temperatures can be controlled during the simultaneous occurrence of a PMH surge and loss of offsite power.

In sum, the Oyster Creek Hurricane Flood Emergency Procedure 520 needs to be modified to address the operational and mechanical problems that would ensue during a PMH exceeding the elevation of the ESW pump motors. Remote sensing of the water level in the intake structure should be provided for the control room operators. The flood emergency procedure should be practiced to identify problems that would be encountered in an actual emergency.

No technical specifications which address emergency flood procedures are available for the Oyster Creek Plant. Plant technical specifications which require initiation of shutdown when the water level reaches 4.5 feet msl are recommended. Clearly, the plant should not continue to operate while the intake water elevation exceeds the intake structure deck elevation at 6.0 feet msl.

3.4 SAFETY-RELATED WATER SUPPLY - ULTIMATE HEAT SINK (SEP TOPIC II-3.C)

3.4.1 Topic Background

This topic reviews the acceptability of a particular feature of the cooling water system, namely, the ultimate heat sink (UHS). The review is based on current criteria contained in Regulatory Guide 1.27, Rev. 2, which is an interpretation of General Design Criterion (GDC) 44, "Cooling Water," and GDC 2, "Design Bases For Protection Against Natural Phenomena," to 10CFR50, Appendix A. GDC 44 requires, in part, that suitable redundancy of features be provided for cooling water systems to ensure that they can perform their safety function. GDC 2 requires, in part, that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena without loss of capability to perform their safety functions. The NRC's Regulatory Requirements Review Committee specifically stated that Regulatory Guide 1.27 must be considered for backfitting operating reactors. This guide is used to determine whether the facility design complies with current criteria or achieves equivalent goals by alternate methods.

The UHS, as reviewed under this topic, is that complex of water sources, including necessary retaining structures (e.g., a pond with its dam or a cooling tower supply basin) and the canals or conduits connecting the sources to the cooling water system intake structures, but excludes the intake structures themselves. The UHS performs two principal safety functions: (1) dissipation of residual heat after reactor shutdown and (2) dissipation of residual heat after an accident. Availability of an adequate supply of water for the UHS is a basic requirement for any nuclear power plant. Since there are various methods of satisfying the requirement, UHS designs tend to be unique to each nuclear plant, depending upon its particular geographical location. Regulatory Guide 1.27 provides UHS examples that the NRC staff has found acceptable.

The UHS must be able to dissipate the maximum possible total heat generated at the plant, including the effects of a loss-of-coolant accident (LOCA) under the worst combination of adverse environmental conditions. The maximum temperature conditions of an UHS such as a cooling pond may significantly limit its capability to dissipate the heat load following a LOCA or plant shutdown, while maximum temperature may not be a significant concern for a UHS such as a large lake, river, or ocean.

Because of the importance of the UHS, it should be able to perform its safety function during and following the most severe natural phenomena or accidents postulated at the site. In addition, the sink safety functions should be ensured during other applicable site-related events that may be caused by less severe natural phenomena and accidents in reasonable combination.

3.4.2 Topic Review Criteria

General review topics applicable to this SEP Topic are presented in Standard Review Plan Sections 2.4.8, 2.4.9, 2.4.11, and 9.2.5.

The specific criteria by which the UHS was evaluated in this topic review are taken from Regulatory Guide 1.27, "Ultimate Heat Sink For Nuclear Power Plants." Regulatory Guide 1.27 criteria are as follows:

"1. The ultimate heat sink should be capable of providing sufficient cooling for at least 30 days (a) to permit simultaneous safe shutdown and cooldown of all nuclear reactor units that it serves and to maintain them in a safe shutdown condition, and (b) in the event of an accident in one unit, to limit the effects of that accident safely, to permit simultaneous and safe shutdown of the remaining units, and to maintain them in a safe shutdown condition. Procedures for ensuring a continued capability after 30 days should be available.

2. The ultimate heat sink complex, whether composed of single or multiple water sources, should be capable of withstanding, without loss of the sink safety functions specified in regulatory position 1, the following events:

   a. the most severe natural phenomena expected at the site, with appropriate ambient conditions, but with no two or more such phenomena occurring simultaneously,

   b. the site-related events (e.g., transportation accident, river diversion) that historically have occurred or that may occur during the plant lifetime,

c. reasonably probable combinations of less severe natural phenomena and/or site-related events.

d. a single failure of manmade structural features.

3. The ultimate heat sink should consist of at least two sources of water, including their retaining structures, each with the capability to perform the safety functions specified in regulatory position 1, unless it can be demonstrated that there is an extremely low probability of losing the capability of a single source.

4. The technical specifications for the plant should include provisions for actions to be taken in the event that conditions threaten partial loss of the capability of the ultimate heat sink or the plant temporarily does not satisfy regulatory positions 1 and 3 during operation."

In addition to Regulatory Guide 1.27, clarifications are contained in Standard Review Plan (SRP), Sections 2.4.11, "Cooling Water Supply," 2.4.8, "Cooling Water Canals and Reservoirs," and 9.25, "Ultimate Heat Sink."

3.4.3 Topic Evaluation

The UHS for Oyster Creek Nuclear Generating Station is Barnegat Bay, from which water is drawn by an inlet canal and returned by a discharge canal. The inlet canal is 140 feet wide, 10 feet deep, and lined with riprap covered with a layer of 4 inches of crushed stone bonded with asphalt. The inlet canal follows the South Branch Forked River. The discharge canal is 100 feet wide and lined similarly to the inlet canal. The discharge canal follows Oyster Creek back to the bay. The Oyster Creek UHS is shared with the nearby proposed Forked River Nuclear Station.

In Reference 3, the Licensee stated that the primary UHS source is the open canal leading from Barnegat Bay to a pump structure adjacent to the plant. An alternate UHS source is an isolation condenser system that provides cooling of the reactor core in the event that reactor feedwater capability is lost and other heat removal systems become inoperative. This alternate source of nuclear service cooling water is also a once-through system and operates by natural circulation without the need for driving power other than the dc electrical power needed to put the system into operation. Water stored in the two isolation condensers and kept at full level during standby can be supplemented during condenser operation from the 525,000-gallon condensate storage tank, using the condensate transfer pumps, and from the fire pond, using either of two diesel-driven fire pumps.

3.4.3.1 Vulnerability of the UHS to Seismic Phenomena

The stability of the intake and discharge canal banks will be studied in more detail in SEP Topic II-4.D, "Stability of Slopes." This aspect is outside the scope of this TER.

3.4.3.2 Vulnerability of the UHS to Probable Maximum Hurricane

In Reference 3, the Licensee concludes that:

"During the occurrence of a probable maximum hurricane (PMH) flood, the nuclear service water pumps will be underwater, and inoperable, so the required 30-day water supply is not assured from the intake structure. In this situation the Oyster Creek Procedure 520 (Appendix A1) will be implemented and the isolation condensers will be used to serve for residual heat removal necessary for safe shutdown of the reactor. Studies are needed to recommend definite changes/solutions to the problem of assuring continuous functional availability of N.S.W pumps under this condition."

In addition, the Licensee concluded that the fire pumps at the fire pond will also be submerged, inoperable, and therefore unable to supply supplemental water to the isolation condensers.

In Reference 26, the Licensee provided the following additional information concerning the consequences of a PMH:

"o It is not expected that the hurricane itself will have any appreciable effect on the canal banks. Using time/water level relationships presented in the Forked River PSAR (Docket 50-263), Amendment 14 (Appendix 2B), the following conclusions can be drawn:

(a) The rise in water will, in itself, have a stablizing effect on the canal banks.

(b) Wave action will be minor in the critical areas of the canal, west of Route 9. The substructures of the highway and railroad bridge near Route 9 will cause any significant waves to dissipate and lose form.

(c) Wave action on a sand bank, as along a sea shore, erodes by undermining small slip surfaces over long periods of time. Within the short time spar stulated, about symmetrical tide cycle, the volume of eroded material will be very small.

o The maximum flood water will tend to saturate the canal banks, laterally during the rise cycle and vertically during the period when flooding overtops the banks. The results of this occurrence have been examined. The findings are summarized in the following:

(a) Transient water levels resulting from wave action will not affect the infiltration rate.

(b) The rapid infiltration will result in less than full saturation. Some 20% of the voids will be filled with entrapped air.

(c) Within the time span of the PMH the banks will not be partially saturated to their full extent. During the drawdown cycle drainage will be bi-directional; i.e., toward the canal and into the unsaturated zone inland of the canal simultaneously.

(d) Assuming the worst possible failure mode our analysis indicates that the drawdown of the intake canal could block no more than 25% of the total canal flow volume."

The Licensee has determined that the UHS (i.e., that complex of water sources, including necessary retaining structures and the canals or conduits connecting the source with, but not including, the cooling water systems intake structures for a nuclear power unit) has a low probability of losing the capability of the canal as a water source. This information will be verified under other SEP Topics including II-4.D, "Slope Stability."

However, the Licensee has not demonstrated that, during a PMH, use of the Oyster Creek Procedure 520 is sufficient to ensure that the safe shutdown of the reactor can be maintained for 30 days. The procedure relies on the use of the isolation condenser which has two sources of supply water. The capability of the isolation condenser is described in Reference 27. Each isolation condenser shell contains a minimum of 22,730 gallons, which represents 11,060 gallons of water above the tubes. Makeup to the isolation condensers is provided by either the condensate transfer system (normal source) or the fire protection system. The two condensate transfer pumps receive their power from the same electrical bus. Power can be supplied by the diesel generators, but the pumps will not start automatically and must be brought onto the diesel bus manually. Assuming the loss of offsite power concurrent with the PMH and a single failure on the bus common to both condensate tranfer pumps, no makeup capability exists to assure a continuous 30-day water supply.

Although the UHS complex is not significantly affected by a PMH, the Licensee has indicated that the plant is not designed to withstand the resulting high water and must rely on an emergency procedure. Because the makeup sources for the isolation condensers are susceptible to single failure and flooding, the plant does not have a means for maintaining a safe shutdown. As a consequence, the Oyster Creek facility does not meet Criteria 1 and 2 following a PMH.

3.4.3.3 Vulnerability of the UHS to Flooding Due to PMF of Oyster Creek and the South Branch Forked River

In Reference 3, the Licensee stated that "during the occurrence of probable maximum floods from streams, the plant does have the capability to meet the regulatory requirement of providing a minimum of 30 days safety-related water supply from the intake structure." This conclusion is based upon analysis of PMF of Oyster Creek and the South Branch Forked River. Since the drainage basins are small, flooding of either Oyster Creek or the South Branch Forked River will not threaten the UHS complex.

3.4.3.4 Vulnerability of the UHS to Missiles

In Reference 3, the Licensee stated that "there is no covering provided for any part of the intake structure. Consequently all nuclear service water pumps and associated facilities are subject to damage from missiles." The consequences of missile damage on other safety-related structures and equipment should be evaluated in accordance with General Design Criterion 4, "Environmental and Missile Design Bases," using guidance provided by the following:

- o Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles"
- o Regulatory Guide 1.117, "Tornado Design Classification"
- o Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants"
- o Regulatory Guide 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites."

3.4.3.5 Vulnerability of the UHS to Reasonably Probable Combinations of Less Severe Natural Phenomena and/or Site-Related Events

In References 2 and 3, the Licensee did not describe the vulnerability of the UHS to reasonably probable combinations of less severe natural phenomena and/or site-related events. A review of the UHS design compared to less severe natural or site-related events did not identify reasonably probable combinations which could effect a significant loss of heat sink function.

In Reference 12, the Licensee did present an analysis of the effects to the banks of the canal of a combination of PMH with resulting high water and an earthquake having a horizontal acceleration of 0.11 g. The effect of a PMH on the canal banks is discussed in Subsection 3.4.3.2. With respect to the earthquake, the Licensee stated:

> "The examination of the canal banks assuming full saturation an an 0.11 g earthquake reveal the following:
>
> a. The smaller earthquake acting on saturated soils will produce slump zones no greater than earthquake acting on drained soils.
>
> b. The evaluation of the liquefaction potential of the soils in the canal bank considered in-situ of the size of the earthquake or the degree of saturation. Therefore, the occurrence of an earthquake simultaneously with the hurricane and the flood does not alter the conclusions with respect to the safety of the banks with respect to liquefaction.
>
> In considering the effects of the combined phenomena on the stability of earth banks it should be recognized that any adjustment in bank configuration is in the direction of increasing stability. Therefore, the effects are not additive. At some point the bank configuration attains a degree of stability that permits it to withstand additional disruptive forces without further alteration."

The Licensee concluded that there is an extremely low probability of losing the capability of the canal as a water source.

The probability of occurrence of a PMH simultaneously with a 0.11 g (conservative OBE) earthquake is smaller than the probability of occurrence of the most severe natural phenomena. The capability of the UHS to withstand the effects of these concurrent phenomena on the canal banks demonstrates the ability of the UHS to also withstand reasonable probable combination of less severe natural or site-related events.

3.4.3.6 Vulnerablility of the UHS to a Single Failure on Manmade Structural Features

In References 2 and 3, the Licensee did not describe the vulnerability of the UHS to a single failure of manmade structural features. No single failure of any structural feature of the intake or discharge canal can result in a loss of heat sink function. As described in Subsection 3.4.3.1, the failure of the bridges over the intake canal will not prevent sufficient flow of emergency cooling water to the Oyster Creek intake structure. Therefore, it can be concluded that the UHS satisfies Criterion 2 with respect to single failure of manmade structural features.

3.4.3.7 Vulnerability of the UHS to Low Water Considerations

In Reference 3, the Licensee discussed the vulnerability of the UHS to ice, seaweed, and silt, and concluded that they do not pose a problem serious enough to block the necessary cooling water inflow required by the nuclear service water pumps. Among the three previously identified hazards, the effect due to seaweed accumulation is the most limiting. A licensee event report (LER) [28] described a reportable occurrence caused by clogging of the traveling screens by seaweed. In Reference 28, the Licensee stated:

> "Environmental studies were in progress on April 15 and observations made at the time revealed that, due to strong north-northwest winds, usually large amounts of Ulva (sea lettuce) were collecting at the mouth of Forked River. Observations made at the mouths of Oyster Creek (plant discharge south of Forked River) and Cedar Creek (north of Forked River) did not indicate any unusual amounts of sea lettuce. However, the mouth

of Forked River was reported to be thick with sea lettuce from the water surface to the river bottom.

The sea lettuce apparently was carried into the intake canal and impinged on the intake screens. Due to circulating currents at the intake structure, most of the material is carried into the north side of the intake. The traveling screens and screen wash system were unable to keep up with the amount of sea lettuce deposited on the screens. This restricted the flow of water across the screens resulting in the circulating water pump lowering the water level in the north side of the intake structure to below the Emergency Service Water pump suctions."

Due to the circulating currents at the intake structure, most of the seaweed was carried into the north side of the intake structure. The south side was relatively unaffected. Each half of the intake structure houses three traveling screens, two circulating water pumps, and two emergency service water pumps from one loop and other components. The emergency service water system provides cooling to the containment spray heat exchangers and, therefore, is required to provide the UHS for the energy release in the event of a LOCA. The containment spray system removes the heat energy from the containment. Each of the two loops contains two emergency service water pumps, two containment spray pumps, and two heat exchangers. The flow from one pump in either loop is more than ample to provide the required heat removal capability. The Licensee stated that "the safety significance is considered minimal." The Licensee-proposed corrective action was to upgrade the materials used in, and improve the trasn removal capacity of, the traveling screens, trash rack, and screen wash system as well as to implement cathode protection of the screens and install new high pressure screen wash pumps.

The deposition of seaweed on the intake structure resulted in the loss of one-half of the intake structure capacity until the circulating water pumps were stopped, permitting the intake structure to refill. It could be assumed that the same condition (i.e., heavy seaweed in the canal) could exist during the period when the UHS is required to be available following a LOCA. Although the deposition rate would be slower due to reduced water flow velocity, the trash removal capacity must be sufficient to ensure adequate emergency cooling water flow. The Licensee's proposed corrective action to improve the trash removal capacity of the traveling screens should be implemented.

In References 2 and 3, the Licensee did not discuss the low water conditions resulting from surges, seiches, or tsunami. However, in Reference 21, the Licensee stated that:

> "The extreme low tide elevation to be expected on the west shore of Barnegat Bay was calculated to be (-) 3.4 feet MSL. The low tide elevation will be slightly less as a result of small hydraulic losses in the intake canal, both at the make-up water pump structure and at the nuclear service water pump structure. Assuming these losses to be 1.0 foot during storm conditions, the extreme low water level at both pump structures will be (-) 4.4 feet MSL. The low water elevation will not affect the capability of any pump in either structure to perform adequately and safely."

The Licensee has not verified that the design low water level was determined with consideration for the effect of setdown from a probable maximum meteorological event. Should the Licensee identify a credible event which jeopardizes the level of water in the intake canal, a technical specification should be developed which precludes operation of the reactor when the water level drops below the nuclear service water pump suction elevation. At present, however, the plant has a backup supply of water in the fire protection pond which acts as an UHS for this event and for other events resulting in a loss of water in the intake canal.

3.4.4 Conclusion

Criterion 1 of Regulatory Guide 1.27 was established for heat sinks where the supply may be limited and/or the temperature of plant intake water from the heat sink may become critical. Similarly, Criterion 2 was established to ensure that the heat sink function would not be lost due to natural phenomena, site-related events, or a single failure of manmade structural features.

Criterion 3 was established to provide a high level of assurance that a plant's UHS would be available when needed. For a once-through cooling system such as that found at the Oyster Creek plant, the Regulatory Guide suggests that there be at least two aqueducts connecting the plant with Barnegat Bay.

In this case, given the existence of the intake structure, at least two discharge aqueducts are recommended in design to carry the cooling water away, precluding plant flooding. This criterion holds unless it can be demonstrated that the probability is extremely low that a single aqueduct will fail to function as a result of natural or site-related phenomena. An UHS design that satisfies the intent of Criteria 2 and 3 then must also be capable of providing sufficient cooling for simultaneous safe shutdown and cooldown of all nuclear reactor units that it serves and of maintaining them in a safe shutdown condition for 30 days as described in Criterion 1.

Because some sections of the review of the UHS have not yet been completed, it cannot be concluded whether the Oyster Creek UHS complies with Criterion 2. Pending a review of SEP Topic II-4.D, the UHS complex may be shown to be capable of withstanding, without loss of the sink safety function, the following events:

- o the site-related events that historically have occurred or that may occur during the plant lifetime
- o reasonably probable condition of less severe natural phenomena and/or site-related events
- o a single failure of manmade structural features.

However, this evaluation indicates that the primary UHS complex (i.e., the intake and discharge canals) is not significantly affected by the most severe natural phenomena (i.e., the PMH). Further, the Licensee has confirmed that the plant must rely upon the alternate cooling path and associated water sources. This alternate mode is the isolation condensers and the water in the condensate storage tanks and fire pond. Because the makeup sources for the isolation condensers are susceptible to single failure and flooding, the plant does not have a means for maintaining a safe shutdown. As a consequence, the Oyster Creek UHS is not capable of withstanding, without loss of the sink safety function, the most severe natural phenomena expected at the site.

The Oyster Creek UHS does not comply with Criterion 3. The Licensee has not demonstrated that there is an extremely low probability of losing the capability of a single source. Specifically, the current UHS complex is susceptible to seaweed accumulation that inhibits the performance of the intake systems. In addition, the Licensee has not verified that the design low water level considered the effect of setdown from a probable maximum meteorological event.

Since the Oyster Creek UHS partially complies with Criterion 2 and does not comply with Criterion 3, it cannot be concluded that the UHS is capable of providing sufficient cooling for simultaneous safe shutdown and cooldown of all nuclear reactor units that it serves and of maintaining them in a safe shutdown condition for 30 days.

Criterion 4 requires that the plant technical specifications include provisions for actions to be taken in the event that conditions threaten partial loss of the UHS. This criterion was established to ensure that the manner in which plant technical specifications were written was such that the plant would be placed in a safe condition or provisions would be implemented if a condition existed which threatened the availability of the UHS. An example of such a condition might be the prediction of a severe flood which would jeopardize a UHS dike or retaining structure, a severe drought with the potential to reduce the capacity of a cooling pond, or a prediction of severe river icing conditions which could preclude or inhibit water flow for a once-through cooling system. In each of these situations, technical specifications requiring the plant to be placed in a safe condition or implementation of procedures to mitigate the consequences of a threatened partial loss of the UHS would be prudent. The Licensee has not addressed this criterion and does not have technical specifications which include provisions for actions to be taken in the event that the plant requires protection from high water during severe hurricane conditions. Since the Licensee has confirmed that conditions may threaten a partial loss of the UHS, it can be concluded that the Oyster Creek facility does not comply with Criterion 4.

4. CONCLUSIONS

The following conclusions identify those site features, protection structures, or procedures which are acceptable or unacceptable in comparison with present licensing criteria. Those issues which are unresolved or will be resolved in interface topics are also identified. Bracketed information summarizes the status of each SEP Topic.

4.1 SEP TOPIC II-3.A, HYDROLOGIC DESCRIPTION

For the purpose of this review, the hydrologic environment has been adequately described. There are no outstanding issues within this topic. [Acceptable]

4.2 SEP TOPIC II-3.B, FLOODING POTENTIAL AND PROTECTION REQUIREMENTS

Roofs - Roofs of safety-related buildings were not designed to be protected from a PMP event. Roof structural modifications are necessary in order to comply with present NRC licensing standards. [Unacceptable - Major change required.]

Local Ponding - Local PMP ponding will cause flooding in the southwest corner of the off-gas building. Minor drainageway modifications are recommended to bring the site drainage system into compliance. [Unacceptable - Minor change required.]

Groundwater - Groundwater ponding to plant grade (elevation 23 feet msl) should be considered a credible event and should be evaluated under SEP Topic III-3.A. [Interface Topic Resolution Needed.]

PMF - The PMP-generated PMF of Oyster Creek and the South Branch Forked River does not pose hazards to the site. [Acceptable.]

PMH - The PMH surge elevation does not affect safety-related structures at plant grade (elevation 23.0 feet msl). However, surge levels are higher than the elevations of circulating water pumps, emergency service water pumps, and diesel-driven fire pumps. Oyster Creek Hurricane Emergency Procedure 520 does not adequately protect the plant from this PHM event. Modifications to plant equipment and procedures are recommended. Specifically, remote sensing of intake canal water levels should be provided. A single failure-proof access to a long-term cooling water supply should be provided for use during the PMH event. [Unacceptable - As a result of II-3.B.1 evaluation.]

4.3 SEP TOPIC II-3.B.1, EMERGENCY PROCEDURES AND TECHNICAL SPECIFICATIONS

Technical Specifications - There are presently no Oyster Creek plant technical specifications which relate to flooding. Technical specifications are recommended which would limit plant operation during high water conditions in the intake canal. [Unacceptable - Major change required.]

Emergency Procedures - The Oyster Creek Plant Hurricane Emergency Procedure 520 does not adequately protect the plant from the consequences of a PMH occurring over the Atlantic Ocean. Modifications to the plant are recommended. Specifically, a single failure-proof pathway to a long-term cooling water supply should be made available for use during the PMH event which initiates Oyster Creek Emergency Procedure 520. [Unacceptable - Major change required.]

4.4 SEP TOPIC II-3.C, ULTIMATE HEAT SINK

The Oyster Creek ultimate heat sink is not available during a postulated PMH event. Although the ultimate heat sink is available (i.e., the water in the intake canal) during the PMH, access to the ultimate heat sink during the PMH event is precluded. Further evaluation under interface topic II-4.D is required to assess full compliance with Regulatory Guide 1.27. Full compliance with Regulatory Guide 1.27 has not been demonstrated. [Interface Topic Resolution Needed.]

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