May 26, 2006

MEMORANDUM TO: Melvyn N. Leach, Deputy Director for Incident Response
Office of Nuclear Security and Incident Response

FROM: Catherine Haney, Director ***/RA/***
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

SUBJECT: ACTIONS TO BE TAKEN IN RESPONSE TO THE HURRICANE LESSONS LEARNED TASK FORCE REPORT (WITS NO. 200600198, TAC NO. MD1832)

In the March 30, 2006, final report of the 2005 Hurricane Season Lessons Learned Task Force, the Office of Nuclear Reactor Regulation was assigned the action to develop improved tools to enable more effective communications of plant design information.

Enclosed are (1) an overview of nuclear power plant design to natural phenomena, and (2) individual plant fact sheets giving information on wind, tornado, hurricane, and external flood design for the following 12 coastal plant sites most susceptible to the effects of hurricanes:

- Brunswick
- Crystal River
- Diablo Canyon
- Farley
- Grand Gulf
- Oyster Creek
- River Bend
- San Onofre
- South Texas
- St. Lucie
- Turkey Point
- Waterford

This action closes out NRR action on WITS No. 200600198 for Recommendation 4 in the Task Force Report 2005 Hurricane Season Lessons Learned Final Report dated March 30, 2006.

Enclosures:
1. Nuclear Power Plant Design for Natural Phenomena
2. Individual Plant Fact Sheets

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DISTRIBUTION: **WITS 200600198**

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DTerao	RidsNrrDorlLple (LRaghavan)	RidsRgnIVDpr
BVaidya		

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Nuclear Power Plant Design for Natural Phenomena

U.S. Nuclear Regulatory Commission (NRC) regulations require that nuclear power plants be designed to withstand the effects of natural phenomena such as hurricanes, tornadoes, earthquakes, floods, and huge ocean waves (tsunamis). Nuclear power plant designs consider the most severe natural phenomena that have been historically reported for the plant site and surrounding area. Plant designs also include margin to account for inaccuracy in this information. The historical data are converted into specific design parameters that are used to design nuclear power plants for these natural phenomena using NRC-approved industry codes and standards and NRC regulatory guidance documents.

Each nuclear power plant is, therefore, designed to a specific magnitude or strength of a natural phenomenon that is appropriate for the plant site and surrounding area. For example, a nuclear plant in Texas or Florida (where earthquakes are of small magnitude and rarely occur) would not be designed for the same earthquake loading as a nuclear plant in California (where earthquakes are more severe and common).

The NRC further requires that the designs conservatively address the combined effects of the natural phenomena with the effects of accident conditions at the plant. For example, a nuclear plant must be designed to accommodate the effects of a simultaneous occurrence of a severe earthquake with a rupture of the largest pipe in the reactor coolant system in the plant.

The overall process used to design nuclear power plants for natural phenomena is reviewed by the NRC to ensure compliance with NRC requirements specified in the *Code of Federal Regulations* prior to the NRC issuing an operating license to a nuclear utility company.

The following tables give more detailed information on the levels and categories of natural phenomena. Enclosure 2 contains plant-specific Fact Sheets for certain nuclear power plants more likely to be subject to natural phenomena.

Nuclear Power Plant Response to Natural Phenomena

Each nuclear power plant has plant procedures, NRC-approved Emergency Operating Procedures and Emergency Action Levels that specify actions plant operators take to protect the public health and safety. These actions include safely shutting down the plant, and maintaining it in that condition. Plant operators also declare various increasing levels of alerts, such as the following:

- Notice of Unusual Event
- Alert
- Site Area Emergency
- General Emergency

These alert levels invoke escalated responses from the plant and local, State, and Federal governments with appropriate urgency.

If a plant shuts down, the NRC staff reviews and determines, in conjunction with other local, State, and Federal agencies, whether adequate protection of the health and safety of the public exists to support restart of the plant. This determination is based on inspections, repairs, compensatory measures (as necessary), and evaluations of offsite emergency preparedness in accordance with established NRC procedures.

General Information Related to Natural Phenomena Levels

Tables 1, 2, 2A, 3, and 3A relate categories, damage scales, intensity regions, magnitudes, and intensity scales of natural phenomena with common terms and knowledge used to describe the phenomena. However, it should be noted that nuclear plants are designed to specific wind speeds and water levels rather than categories or scales. Also, as previously mentioned, plant designs also include margin to account for inaccuracy in this information.

Table 1 — Saffir-Simpson Scale of Hurricanes

Category	Maximum Sustained Wind Speed (miles per hour [mph])	Storm Surge (feet)
1	74-95	3-5
2	96-110	6-8
3	111-130	9-12
4	131-155	13-18
5	156 +	19 +

Table 2 — Fujita Tornado Damage Scale

(Developed in 1971 by T. Theodore Fujita of the University of Chicago)

Scale	Wind Estimate * (mph)	Typical Damage
F0	< 73	Light Damage: Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73 - 112	Moderate Damage: Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113 - 156	Considerable Damage: Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	157 - 206	Severe Damage: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207 - 260	Devastating Damage: Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261 - 318	Incredible Damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

* Do not use F-scale winds literally. These wind-speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place — even from building to building. Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.

Tornadoes can be characterized by a set of parameters which are important for plant structural design and siting. These parameters include (1) geographlcal frequency of occurrence; (2) maximum and rotational wind speed, (3) radius of maximum rotational wind speed, and (4) pressure drop across the tornado, as shown in Table 2A.

Table 2A — Approximate Tornado Characteristics Used in Nuclear Plant Design

(From NRC Regulatory Guide 1.76, Design-Basis Tornado for Nuclear Plants)

Tornado Intensity Regions of US (see Fig. 1)	Maximum Wind Speed (mph)[a]	Rotational Speed (mph)	Radius of Maximum Rotational Speed (feet)	Pressure Drop (psi)
I	360	290	150	3
II	300	240	150	2.25
III	240	190	150	1.5

(a) Maximun wind speed is the sum of the rotational speed and the speed the tornado travels across the ground.

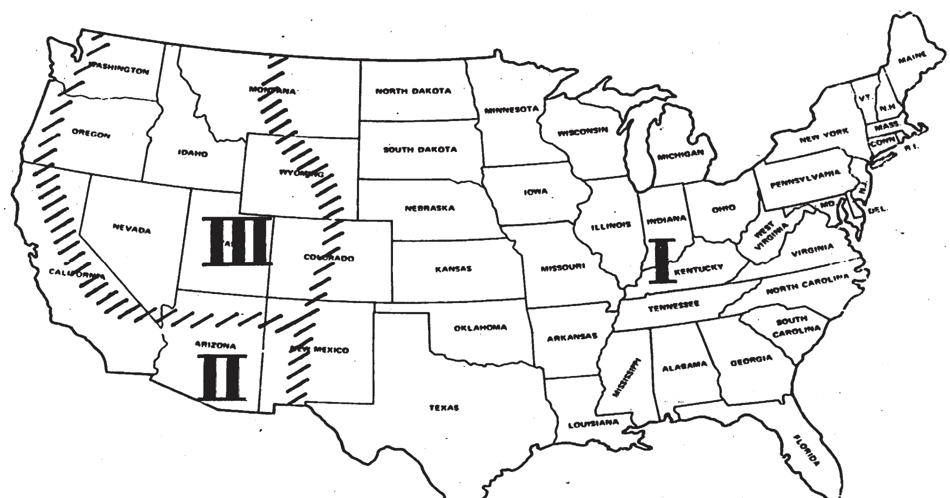

Figure 1. TORNADO INTENSITY REGIONS

Table 3 — Earthquake Severity

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Table 3A — Modified Mercalli Intensity Scale for Earthquakes

(From the Federal Emergency Management Agency)

I	People do not feel any earth movement.
II	A few people might notice movement if they are at rest and/or on the upper floors of tall buildings.
III	Many people indoors feel movement. Hanging objects swing back and forth. People outdoors might not realize that an earthquake is occurring.
IV	Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. The earthquake feels like a heavy truck hitting the walls. A few people outdoors may feel movement. Parked cars rock.
V	Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.
VI	Everyone feels movement. People have trouble walking. Objects fall from shelves. Pictures fall off walls. Furniture moves. Plaster in walls might crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.

VIII	Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly-built structures suffer severe damage. Tree branches break. Hillsides might crack if the ground is wet. Water levels in wells might change.
IX	Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas. Railroad tracks are bent slightly.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed. Railroad tracks are badly bent.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Brunswick Steam Electric Plant, Units 1 & 2

Wind Design

Brunswick Steam Electric Plant (BSEP) is located approximately 2 miles west of the Cape Fear River, and approximately 5 miles west of the Atlantic Ocean. Because of the curvature of the coastline in this area, the ocean also lies about 4 miles south. The plant is subjected to the full force of hurricane winds. Therefore, it is designed to withstand sustained winds of up to 135 miles per hour (mph) which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below.

The design of BSEP, Units 1 and 2, for wind loadings is described in the Updated Final Safety Analysis Report (UFSAR), Section 2.3.1.2.7 and 3.3.1.

Tornado Design

The BSEP plants are located in an area of the U.S. where tornadoes occur frequently. All safety-related buildings and structures are designed to withstand tornado wind speeds of up to 300 mph, and a maximum pressure drop of 3 pounds per square inch (psi).

The tornado design is described in UFSAR Sections 2.3.1.2.1 and 3.3.2. UFSAR, Section 3.5.1.4, says the plant is also designed to withstand the impact of tornado-generated missiles such as a corrugated sheet of siding, wood decking, a cedar fence post, and an automobile.

Hurricane Design

The hurricane design for BSEP is based on studies conducted by the Environmental Science Services Administration and the Coastal Engineering Research Center. The design is considered to provide full protection against hurricane winds, tides, and wave action for the worst hurricane reasonably possible at the site. This protection is provided for any intensity hurricane up to and including the probable maximum hurricane (PMH).

The PMH is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The PMH is assumed to approach the plant site along the critical path, and at the optimum rate of movement. For the BSEP site, the PMH results in a probable maximum surge elevation at the intake canal of 22 feet above mean sea level (MSL). The plant grade level is approximately 19.5 feet above MSL. Therefore, the plant has been flood protected to an elevation of 22 feet above MSL (see External Flooding Design below). The plant has also been protected for run-up wave action to above 26 feet.

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. Hrricane design is described in UFSAR, Section 2.4.5.

External Flood Design

The most severe flood conditions at BSEP are associated with the PMH coinciding with local high tides. The intake canal would be expected to surge to 22 feet above MSL during severe storm conditions. The plant grade level is 19.5 feet above MSL. Therefore, the plant has been flood protected to an elevation of 22 feet above MSL. All of the safety-related structures are waterproofed by using access doors with sills above the 22-foot still-water level, or are equipped with positive seals and closure devices when the sills are below 22 feet MSL. Additional protection is provided by a intake canal high level alarm to alert operators to take corrective actions.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane) is described in UFSAR Section 2.4.5.1 and 3.4.

Crystal River, Unit 3

Wind Design

The Crystal River plant is located approximately 1 mile from the Gulf Mexico to the west, and is subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 179 mph which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution (e.g., for flat, open country; flat, open coastal belts; and grassland) and appropriate wind gust factors.

The design of Crystal River 3 for wind loadings is described in the Final Safety Analysis Report (FSAR) Sections 2.3.1.3.1 and 5.2.1.2.5.

Tornado Design

Crystal River is located in an area of the U.S. where tornadoes occur frequently. All safety-related (Class 1) buildings and structures are designed to withstand tornado wind speeds of up to 300 mph combined with a maximum pressure drop of 3 psi. As described in FSAR Section 5.4.5.3, the plant is also designed to withstand the impact of tornado-generated missiles such as a 10-foot pipe, a wooden plank, a utility pole, and an automobile.

Tornado design is described in FSAR Sections 2.3.1.3.3 and 5.2.1.2.6.

Hurricane Design

The height levels reflected below have been corrected from the FSAR to the number of feet above mean low water (MLW). MLW is the zero reference height for this document and is measured at the Crystal River plant intake canal at the Gulf of Mexico.

The hurricane flood design for Crystal River is based on studies conducted by the National Oceanic and Atmospheric Administration, the U.S. Army Corps of Engineers, and other private contractors. The Crystal River plant is designed for a probable maximum hurricane (PMH) which is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The PMH is assumed to approach the plant site along the critical path and at the optimum rate of movement.

The design is considered to provide full protection for all components which must operate for a safe and orderly shutdown of the Crystal River nuclear unit (Class 1 components). This protection is provided for any intensity hurricane up to and including the PMH.

For Crystal River 3, the PMH results in a probable maximum surge elevation of 33.4 feet above mean low water (MLW). The plant grade level is 30.5 above MLW. Buildings housing class 1 components have been designed to withstand a surge of water of 41 feet above MLW which also accounts for wave action and run-up. Specific design characteristics are included in the External Flooding Design below.

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. The hurricane design is described in FSAR Section 2.4.2.

External Flood Design

The probable maximum flood level for the Crystal River site is 33.4 feet, which is the maximum storm tide during a PMH. The plant grade level is 30.5 feet. Therefore, the systems and components inside these buildings are protected from the effects of external flooding by the use of retaining walls, steel and concrete barriers, watertight equipment hatches, and watertight walls and doors. Additional specific provisions for flood protection include administrative procedures which install dewatering pumps to control leakage through doors and walls.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in FSAR Section 2.4.2.

Diablo Canyon Nuclear Power Plant

The plant is located on the Pacific Ocean coastline in San Luis Obispo County, California, approximately 12 miles west-southwest of the city of San Luis Obispo, the county seat. The site is approximately 750 acres near the mouth of Diablo Creek, 165 acres north of Diablo Creek, and 595 acres adjacent to, and south of, Diablo Creek. The annual mean number of days with severe weather conditions, such as tornados and ice storms, at west coast sites is zero.

Tornado Design

The design wind for the plant has a velocity of 80 miles per hour (mph) based on a recurrence interval of 100 years. A gust factor of 1.1 was applied to the design wind. The containment and turbine building were designed for the design wind loads.

Wind loads for buildings other than the containment and the turbine building are in accordance with the International Conference of Building Officials Uniform Building Code, 1967 Edition (UBC). Although the UBC designates the site as being in a 20 pound-per-square foot (psf) zone, it was conservatively assumed for design purposes to be a 25 psf zone. These wind pressures were considered to act on the gross area of the vertical projection of each structure measured above the average level of the adjoining ground. The roof of the building was designed for an uplift pressure to three fourths of the wind pressure for the vertical projection, assumed to act over the entire roof area.

There are no record of hurricanes on the Pacific Coast or squall lines, and these are not a design consideration. However, the plant was designed for tornados. Although there is also not a record of cyclonic-type wind storms, and the plant was not designed to a specific tornado wind speed, the NRC evaluated the building design to a design-basis tornado wind speed of 200 mph, which includes a 157 mph rotational component, a 43 mph translational component, and a differential pressure of 0.86 pounds per square inch (psi) at a rate of 0.36 psi per second. Wind gust factors were assumed only for small structures and critical portions of large structures. Tornado-borne missiles were considered in the design of structures, with site-generated missiles evaluated to determine if they were more severe that the following hypothetical missiles:

- 108 pound, 4-inch x12-inch x 10 feet board at the wind velocity
- 76 pound, 3-inch x 10-foot pipe at one-third wind velocity
- 4000 pound automobile up to 25 feet above ground at one-sixth wind velocity

This tornado is a Fujita Scale F3 in Table 2, and less than Region III in Table 3, of design-basis tornado wind speeds and characteristics.

Wind and tornado loadings are addressed in Diablo Canyon Final Safety Analysis Report (FSAR) Update Section 3.3.

Water Level Design, Including Tsunamis and Flooding

Site flooding include the combined effects of flooding from steams and rivers, a tsunami, wind-generated storm waves, storm-surge, and tides. For flooding from steams and rivers, there is the probable maximum flood (PMF) from the probable maximum precipitation (PMP) with a duration of 24 hours and all culverts plugged. The only stream on the site is Diablo Creek, which collects runoff from a drainage area of 5.2 square miles up from the oceanside. The combination of tsunami, wind-generated storm waves, storm-surge, and tidal effects results in a rise and fall of the ocean surface level relative to a defined datum level, the mean lower low water level (MLLWL). For the plant site, the MLLWL is 2.6 feet below the mean sea level (MSL).

The PMF was found to have a peak discharge of 6878 cubic feet per second, or a volume of 4306 acre-feet for the 24-hour storm. For the tsunami runup and drawdown, the wave heights for distantly-generated and locally-generated (near shore) tsunamis were considered. For distantly-generated tsunamis, the design combined drawdown and wave runup is 9.0 feet and 30 feet, respectively. For near-shore tsunamis, the design combined drawdown and wave runup is 4.4 feet and 34.6 feet. This is the probable maximum surge (PMS) for the site.

There are no dams in the site watershed and the failure of any dams outside the watershed could not generate waves higher than those considered for the PMS.

Water-level design is addressed in Diablo Canyon FSAR Update Section 3.4.

Farley Nuclear Plant, Units 1 & 2

Wind Design

The distance from the Farley Nuclear Plant (FNP) to the nearest Gulf coastline is about 70 miles. The plant is designed to withstand sustained winds of up to 115 mph, which is based on a 100-year recurrence interval[1] as well as tornadic wind speeds as discussed below. The wind design also considers appropriate wind gust factors.

The design of FNP for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Section 3.3, "Wind and Tornado Loadings."

Tornado Design

The FNP is located in an area of the U.S. where tornadoes occur frequently[2]. Safety-related buildings and structures requiring protection are designed to withstand wind pressure from a tornado funnel having a peripheral tangential velocity of up to 300 mph, a forward progression of 60 mph, and a maximum pressure drop of 3 psi[3].

As described in UFSAR Section 3.3.2.1, the plant is also designed to withstand the impact of tornado-generated missiles such as a 114 pound, 12-ft long piece of wood 8 inches in diameter, a 76 pound, 10 ft steel pipe, and a 4000 pound automobile[4].

Tornado design is described in UFSAR Sections 3.3.2, Tornado Loadings,"and 3.5.1, "Missile Barriers and Loadings."

Hurricane Design

UFSAR 3.3.1.2, "Basis for Wind Velocity Selection," reflects hurricane experience on the Gulf Coast. That discussion is summarized in "Wind Design," above. There is no separate discussion of "hurricane design" in the FNP's UFSAR. As FNP is not near a large body of water, surge, seiche and tsunami flooding do not apply to FNP.

External Flood Design

The probably maximum flood (PMF) resulting from the probably maximum precipitation applied to the 8,246 square mile Chattahoochee River Basin above the plant site would have a corresponding water level of 144.2 ft above mean sea level (MSL) considering wind-induced wave runup to 153.3 ft MSL. It was concluded that PMF waters would not reach the plant grade

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[1] SE (NUREG 75/034, May 2, 1975), page 3-3, FSAR page 3.3-1

[2] Frequently as defined in Zone 1 of NRC Reg Guide.

[3] FSAR pages 3.3-2 and 3

[4]Also in the SE, page 3-3.

of 154.5 ft MSL. Section 2.4.10 of the UFSAR states that no doorway or opening of a safety related building will be flooded by the runoff from the PMF

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 2.4.2, “Floods.” Other factors considered in Section 2.4.2 of the NRC staff’s Safety Evaluation of flooding included the effect of dam failures, flooding of the river intake structure and of the onsite storage pond. The Safety Evaluation concluded that the safety of the plant would not be threatened, and that flood waters would not approach plant buildings that are located on a grade elevation of 154.5 ft above MSL.

Grand Gulf Nuclear Station, Unit 1

Wind Design

The Grand Gulf Nuclear Station, Unit 1, is located approximately 200 miles from the Gulf of Mexico and historically, has not been subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 90 mph which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution (e.g., for flat, open country; flat, open coastal belts; and grassland) and appropriate wind gust factors.

The design of Grand Gulf Nuclear Station, Unit 1, for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Sections 2.3.1.2.9 and 3.3.1.

Tornado Design

The Grand Gulf Nuclear Station, Unit 1 is located in an area of the U.S. where tornadoes occur frequently. All safety-related buildings and structures are designed to withstand maximum tornado wind speeds of up to 360 mph and a maximum pressure drop of 3 psi.

The tornado design is described in UFSAR Sections 2.3.1.2.8 and 3.3.2. UFSAR Section 3.5.1.4 says the plant is designed to withstand the impact of tornado-generated missiles such as a wood plank, a steel pipe 6 to 12 inches nominal diameter, a steel rod 1-inch in diameter, a utility pole, and an automobile.

Hurricane Design

The Grand Gulf Nuclear Station, Unit 1 site is not in a coastal region. Hence, consideration of surge and seiche flooding is not warranted. The design considerations for hurricane winds are bounded by the tornadic wind design discussed above.

Hurricane design is described in UFSAR Section 2.4.5.

External Flood Design

The probable maximum flood level for Grand Gulf Nuclear Station, Unit 1, is 103-ft, 0-in. The plant grade level is 132-ft, 6-in. Therefore, flooding effects only apply to the systems and components inside the auxiliary building which are located below the plant grade level. The systems and components inside the auxiliary building are protected from the effects of external flooding by the use of watertight walls and doors. Additional specific provisions for flood protection include administrative procedures to assure that all watertight doors will be closed in the event of a flood warning. If local seepage occurs through the walls, it will be controlled by sumps and sump pumps.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 3.4.1.

Oyster Creek Nuclear Generating Station

Wind Design

Oyster Creek Nuclear Generating Station (Oyster Creek) is located on the coastal pine barrens of New Jersey in Lacey and Ocean Townships, Ocean County, approximately 2 miles from the Atlantic Ocean and historically has not been subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 100 mph, which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution and appropriate wind gust factors.

The design of Oyster Creek for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Sections 2.3.2.1.1, 2.3.2.1.2, and 3.3.1.1.

Tornado Design

The Oyster Creek facility was originally designed and constructed before the NRC requirements for tornado design were in effect. In the original design for Oyster Creek, the plant structures were designed for a worst-case storm that would be expected in 100 years. A tornado was also considered as a possible source of higher wind loadings. However, the probability of a tornado occurring at the Oyster Creek site was 1.81 percent for a 40-year plant life, or once in 2190 years. At the time of licensing, the NRC staff determined that the safety margin was adequate considering the historical records for tornado occurrences at the site. All safety-related buildings and structures were originally designed to withstand the maximum wind speed of 100 mph for the 100-year wind storm. Subsequently, the reactor building, control room building, intake structure, and ventilation stack were modified or evaluated for their capability to withstand higher wind and tornado loads.

The tornado design is described in UFSAR Sections 2.3.1.2.2 and 3.3.2. As described in UFSAR Section 3.5, the plant is also designed to withstand the impact of tornado-generated missiles such as valve components, vessel head bolts, and pieces of pipe.

Hurricane Design

Oyster Creek is designed for a probable maximum hurricane (PMH), which is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The PMH is assumed to approach the plant site along the critical path and at the optimum rate of movement. For Oyster Creek, the PMH results in a probable maximum surge elevation of 22 ft. above mean sea level (MSL). With the exception of the circulating water intake structure, the plant grade level is 23 ft. above MSL. Flooding of this structure would require shutdown of the circulating water and emergency service water pumps. The utility has emergency plant procedures in place that require appropriate actions (including plant shutdown) when water reaches a predetermined level as to ensure for the safe shutdown of the plant. Therefore, the plant is designed to withstand a surge of water of 22 ft above MSL reaching the plant structures.

The hurricane flood design for Oyster Creek is based on the historical data on nine severe hurricanes which threatened the plant site between 1935 and 1967. The highest observed water elevation was 4 ft. 6 in. above MSL. Water level would need to reach the plant grade level 6 ft. MSL before it would seep into any of the Oyster Creek buildings.

The hurricane design is described in UFSAR Section 2.3.1.2.1.

External Flood Design

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Sections 2.4.2 and 2.4.5.

As discussed in UFSAR Section 2.4.5, due to the site proximity to Barneget Bay and the Atlantic Coast, flooding water levels are influenced solely by storm and tidal actions. Therefore, the flooding due to a hurricane is considered to be the limiting case.

River Bend Station

Wind Design

The River Bend Station is located approximately 100 miles from the Gulf of Mexico and historically, has not been subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 100 mph which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution (e.g., for flat, open country) and appropriate wind gust factors.

The design of the River Bend Station for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Section 3.3.1.

Tornado Design

The River Bend Station is located in an area of the U.S. where tornadoes occur frequently. All safety-related buildings and structures are designed to withstand tornado wind speeds of up to 360 mph, and a maximum pressure drop of 3 psi. As described in UFSAR Section 3.5.1.4, the plant is also designed to withstand the impact of tornado-generated missiles such as a wood plank, a steel pipe 6 to 12 inches nominal diameter, a steel rod 1-inch in diameter, a utility pole, and an automobile.

The tornado design is described in UFSAR Section 3.3.2.

Hurricane Design

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. A hurricane undergoes significant weakening by the time it reaches the River Bend Station site. It is extremely unlikely that there could be a coincident flooding due to hurricane surges and flooding due to the Mississippi River. The occurrence of a hurricane concurrently with the Project Design Flood is, therefore, highly improbable, and is not evaluated in the design.

The hurricane design is described in UFSAR Section 2.4.5.

External Flood Design

The design basis flood level for the River Bend Station site is 70-ft, 0-in. The average plant grade is 94-ft, 6-in. Therefore, flooding effects are applicable only to those systems and components located below the average plant grade. These systems and components are protected from the effects of external flooding by the use of watertight walls and doors. Additional specific provisions for flood protection include administrative procedures to assure that all watertight doors will be closed in the event of a flood warning. If local seepage occurs through the walls, it will be controlled by sumps and sump pumps.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 3.4.1.

San Onofre Nuclear Generating Station, Units 2 and 3

Wind Design

The fastest wind speed recorded at San Diego during the 31 years of record was 31 miles per hour (mph), and was 51 mph in Los Angeles during 25 years of record. The plant is designed to withstand sustained winds of up to 63 mph, which is based on a 100-year recurrence interval and a probable maximum wind speed of 75 mph. The wind design also considers the velocity distribution and appropriate wind gust factors.

The design of San Onofre Nuclear Generating Station (SONGS), Units 2 and 3, for extreme wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Sections 2.3.1.2.9.

Tornado Design

Between 1950 and 1975, a total of 177 tornadic storms were reported in California. Of these, 123 caused little or no damage and were virtually all waterspout or funnel cloud observations. Prior to 1950, California State Climatologist compiled a list of known tornado occurrences in the state. Based on these known facts, the design basis for SONGS 2 and 3 is a maximum total wind speed of 260 mph, and a maximum pressure drop of 1.5 pounds per square inch (psi).

As described in UFSAR Table 3.5.6, the plant is also designed to withstand the impact of tornado-generated missiles such as a 12-foot wood plank, 4 x 12 inches in cross section, traveling at a speed of 220 mph; a 10-foot long 3 inch steel pipe, at 100 mph; an 4000 lb. automobile at 50 mph.

The tornado design is described in UFSAR Section 2.3.1.2.2.

Hurricane Design

Tropical Storms with hurricane force winds (72 mph, or greater) have not been recorded to approach the southwestern United States. Although hurricanes exist several hundred miles to south off of the western coast of Mexico, their impact on the San Onofre area are usually only takes form of a summer thunderstorm.

Hurricane design is described in UFSAR Section 2.3.1.2.1.

External Flood Design

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 2.4.2. For purposes of determining and analyzing potential flood sources, consideration was given to the San Onofre Creek Basin and the foothill drainage area east of the site. The probable maximum flood level (PMFL) for the SONGS 2 and 3 site is 24.1 feet. Topographical feature of the basin would contain this flow and thereby preclude flooding of the site by this source. Any openings and penetrations below the PMFL are either sealed, protected by watertight doors/hatches, protected by waterstops, or analysis has shown that PMF cannot impact safety-related equipment (UFSAR Section 3.4.1.1.2).

Tsunamis caused by active trench system are considered along with those generated by large scale tectonic structures which might be considered capable of generating tsunamis at SONGS. (UFSAR Sections 2.4.5.5, 2.4.6.3.1 and 2.4.6.6). Special structures designed to protect the site include the seawall. The plant grade is at an elevation well above the maximum seawater elevation predicted for the occurrence of a maximum tsunami coincident with storm surge and high tide.

St. Lucie, Units 1 and 2

Wind Design

The St. Lucie site is located on Hutchinson Island, Florida, with the Atlantic Ocean to the east and Indian River to the west. The site is subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 194 mph, which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution (e.g., for flat, open country; flat, open coastal belts; and grassland) and appropriate wind gust factors.

The design of the St. Lucie plants for wind loadings is described in the Updated Final Safety Analysis Report (UFSAR) Sections 2.4.5.1 and 3.3.1.

Tornado Design

The St. Lucie site is located in an area of the U.S. where tornadoes occur frequently. All safety-related buildings and structures are designed to withstand tornado wind speeds of up to 300 mph combined with a maximum pressure drop of 3 psi.

UFSAR Section 3.5.2.2 says the plant is also designed to withstand the impact of tornado-generated missiles such as a 10-foot long timber and an automobile.

The tornado design is described in UFSAR Sections 2.3.1.3 and 3.3.2.

Hurricane Design

The St. Lucie plants are designed for a probable maximum hurricane (PMH) which is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The PMH is assumed to approach the plant site along the critical path and at the optimum rate of movement. For the St. Lucie site, the PMH results in a probable maximum surge elevation of 17.2 feet above mean low water (MLW). The plant grade level is 19 feet above MLW; therefore, the plant is designed to withstand a surge of water of 17.2 feet above MLW. Additional surge and wave run-up protection is discussed in External Flooding Design below.

The hurricane flood design for the St. Lucie site is based on the historical data on 20 hurricanes which have threatened the plant since 1900. The highest observed water elevation was approximately 8 feet above MLW. Water level would need to reach the plant grade level of 19 feet above MLW before it would seep into any of the St. Lucie buildings.

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. The hurricane design is described in the UFSAR Sections 2.4.5.1 and 3.3.1.

External Flood Design

The probable maximum flood level for the St. Lucie site is 17.2 feet above MLW. The plant grade level is 19 feet above MLW. Therefore, the plant is protected from flooding. Additional measures to protect the plant are used such as reinforced concrete flood walls and building entrances elevated to 19.5 feet. Some important safety-related systems and components (Class 1) have additional protection such as their elevation to 22 feet above MLW.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane) is described in UFSAR Sections 2.4.5.9 and 3.4.

South Texas Project Electric Generating Station

Wind Design

The South Texas Project Electric Generating Station is located approximately 10 miles north of Matagorda Bay and is subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 125 mph, which is based on a 100-year recurrence interval as well as tornadic wind speeds as discussed below. The wind design also considers the velocity distribution (e.g., for flat, open country; flat, open coastal belts; and grassland) and appropriate wind gust factors.

The design of the South Texas Project Electric Generating Station for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Section 3.3.

Tornado Design

The South Texas Project Electric Generating Station is located in an area of the U.S. where tornadoes occur frequently. All safety-related buildings and structures are designed to withstand tornado wind speeds of up to 360 mph and a maximum pressure drop of 3 psi.

The tornado design is described in UFSAR Sections 3.3 and 3.5. UFSAR Section 3.5 says the plant is also designed to withstand the impact of tornado-generated missiles such as a 6" diameter, schedule 40 steel pipe, a 13.5" diameter wooden utility pole, or an automobile.

Hurricane Design

The South Texas Project Electric Generating Station is designed for a probable maximum hurricane (PMH) which is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The PMH is assumed to approach the plant site along the critical path and at the optimum rate of movement. For South Texas Project Electric Generating Station site, the PMH results in a probable maximum surge elevation of 26.74 ft. above mean sea level (MSL), which is below the plant grade elevation of 28.0 ft.

The hurricane flood design for the South Texas Project Electric Generating Station is based on the historical data on shown below. The highest observed water elevation was 12.3 ft. above MSL. Water level would need to reach the plant grade level 28 ft. MSL before it would seep into any of the South Texas Project Electric Generating Station buildings.

Hurricane design is described in UFSAR Section 2.4.5. The design considerations for hurricane winds are bounded by tornadic wind design discussed above.

External Flood Design

The maximum water level on a vertical face at the south end of the plant structures is elevation 50.8 ft mean sea level (MSL), which is elevation 22.8 ft above plant grade. This maximum elevation occurs during a quasi-steady-state condition after a breach of the main cooling reservoir (MCR) embankment.

Seismic Category I structures are designed to withstand the maximum flood levels by the following:

- Having external walls and slabs of structures designed to resist the hydrostatic and hydrodynamic forces associated with surge-wave runup and steady-state water level.

- Ensuring the overall stability of the total structure against overturning and sliding due to the hydrostatic and hydrodynamic forces associated with surge-wave runup and steady state water level.

- Ensuring that the total structure will not float due to buoyancy forces.

Leakage from groundwater into the FHB is prevented by the use of waterproofing on exterior wall and slab surfaces located below grade. Sump pumps handle any groundwater inleakage. Leakage of groundwater into the MEAB is prevented by the use of waterproofing on exterior wall and slab surfaces located below grade, and sump pumps are also provided here.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 3.4.

Turkey Point, Units 3 & 4

Wind Design

The Turkey Point units are located on the west shore of Biscayne Bay and are subjected to the full force of hurricane winds. The plant is designed to withstand sustained winds of up to 145 mph, which is based on a 100-year recurrence interval of 122-mph winds as well as tornadic wind speeds as discussed below.

The design of the Turkey Point Plant, Units 3 and 4, for wind loadings is described in the Updated Final Safety Analysis Report (UFSAR), Chapter 5, Appendix 5A, Section 1.3.4.

Tornado Design

The Turkey Point Plants are located in an area of the U.S. where tornadoes occur frequently. All safety-related (Class I) buildings and structures are designed to withstand tornado wind speeds of up to 337 mph combined with a maximum pressure drop of 2.25 psi.

The tornado design for class 1 components at Turkey Point is described in UFSAR Chapter 5, Appendix 5A, Section 1.3.5. UFSAR, Appendix 5E, says the plant is also designed to withstand the impact of tornado-generated missiles such as a corrugated sheet of siding, wood decking, and an automobile.

Hurricane Design

The Turkey Point Plants are designed for a maximum probable hurricane (MPH) which is defined by the National Weather Service as a hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The MPH is assumed to approach the plant site along the critical path and at the optimum rate of movement. For the Turkey Point site, the MPH results in a probable maximum surge elevation of 18.3 feet above mean low water (MLW). The plant grade level is 18 feet above MLW, and has been flood protected to an elevation of 20 feet above MLW. Components vital to safety, with the exception of the intake cooling water (ICW) pumps, are protected against flood tides, and wave runup, to 22 feet above MLW on the east side of the units. The ICW pump motors are protected to 22.5 feet above MLW.

The hurricane flood design for the Turkey Point plants is based on a hurricane wave run-up of 20 feet above MLW. The Army Corps of Engineers determined this criteria to be acceptable. The highest observed water elevation was 10.1 feet above mean sea level in 1965. Water level would need to reach the plant grade level of 18 feet above MLW before it would seep into any of the Turkey Point buildings.

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. The hurricane design for Turkey Point is described in UFSAR Chapter 5, Appendix 5G.

External flood Design

The predicted maximum flood stage resulting from the maximum probable hurricane has been calculated to be 18.3 feet above MLW. The plant grade level is 18 feet above MLW. Therefore, the plant has been flood protected to an elevation of 20 feet above MLW. This is accomplished by the use of a continuous barrier consisting of building exterior walls, flood walls, a flood embankment, and stop logs for the door openings. Additional protection up to 22 feet above MLW has been provided to the east using a continuous barrier consisting of building exterior walls and stop logs for the door openings.

Additional protection against flooding is provided by placing safety equipment on pedestals or providing curbs, use of closed doors with water-tight sills, floor drainage systems with sumps and sump pumps, and water level alarms.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane) is described in UFSAR Chapter 5, Appendix 5G.

Waterford Steam Electric Station, Unit 3

Wind Design

The plant is designed to withstand sustained winds of up to 100 mph which is based on a 100-year recurrence interval. Tornadic wind speeds and hurricane wind speeds are discussed below. The wind design also considers the distribution of extreme winds with height at the site and appropriate wind gust factors.

The design of the Waterford 3 for wind loadings is described in Updated Final Safety Analysis Report (UFSAR) Section 2.3.1.2.1.

Tornado Design

Waterford 3 is located in an area of the U.S. where tornadoes occur, although the chance of a direct strike at the site is slight. A review of the historical data indicates that a conservative estimate of the annual probability of a tornado striking the site is about once every 1585 years. All structures and equipment necessary to initiate and maintain a safe plant shutdown have been designed to withstand short-term loadings resulting from a tornado funnel with a peripheral tangential velocity of 300 mph and a translational velocity of 60 mph with an external pressure drop of 3 psi in 3 seconds.

The plant is also designed to withstand the impact of tornado-generated missiles ranging from metal piping and wooden planks up to a 4000-pound automobile.

The tornado design is described in UFSAR Sections 2.3.1.2.4 and 3.5.1.4.

Hurricane Design

The Waterford 3 nuclear power plant is located approximately 60 miles north of the open waters of the Gulf of Mexico and is not subjected to the full force of hurricane winds or the ocean surge levels that accompany hurricanes.

Waterford is designed for a probable maximum hurricane (PMH) which is defined by the National Weather Service as, “A hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the region involved. The hurricane should approach the point under study along a critical path and at optimum rate of movement.” For the Waterford 3 site, the PMH results in a probable maximum surge elevation of 18 ft.-1 in. above mean sea level (MSL). The maximum effective water level from hurricane induced wind waves was computed to be 23.7 ft. above MSL. The plant grade level is 14 ft.-6 in. above MSL, and the plant is designed to withstand a flood level of 29.25 ft above MSL.

The design considerations for hurricane winds are bounded by tornadic wind design discussed above. Hurricane design is described in UFSAR Section 2.4.5.

External Flood Design

The probable maximum flood level (PMFL) for the Waterford 3 site is 27 ft. above MSL. The plant grade level is 14 ft.-6 in. above MSL. and all structures and equipment necessary to initiate and maintain a safe plant shutdown have been designed to withstand a flood level of 29.25 ft above MSL.

The design of the plant for flooding caused by external sources (e.g., rain, hurricane, dam failure) is described in UFSAR Section 2.4.3.