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Robert L. Mittl General Manager
Nuclear Assurance and Regulation

January 31, 1985

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20814

Attention: Mr. Albert Schwencer, Chief
Licensing Branch 2
Division of Licensing

Gentlemen:

HOPE CREEK GENERATING STATION
DOCKET NO. 50-354
RIVERBORNE MISSILES SUPPLEMENTAL INFORMATION

On December 18, 1984, representatives of PSE&G met with the NRC staff to discuss comments raised by the staff on PSE&G's September 17, 1984 submittal of supplemental information on riverborne missiles. After that meeting, the NRC formally transmitted these comments as questions in a letter to PSE&G on January 9, 1985 (A. Schwencer to R. L. Mittl).

Our response to these questions is attached. In a few instances we are completing required analyses which will be forwarded to you by approximately February 20, 1985.

Should you have any questions or require any additional information on our submittal, please contact R. P. Douglas, Manager - Licensing and Analysis, of our staff.

Very truly yours,

R L Mittl

Attachment

C D. H. Wagner (w/5 sets of attach.)
USNRC Project Licensing Manager

A. R. Blough (w/attach.)
USNRC Senior Resident Inspector

B001
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ADD. J. RIDGELY, ASB
J. WILSON, ASB
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R. JACKOWSKI, EHEB
C. FERRELL, SAB

HOPE CREEK GENERATING STATION
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
RESPONSES TO QUESTIONS IN JANUARY 9, 1985 LETTER
RIVERBORNE MISSILES

Question 1

Your analysis of waterborne missiles has been limited to the hurricane flooding event. a) Using the combined event criteria cited in ANS 2.8-1981, provide your detailed analysis of the water levels associated with the Probable Maximum Flood (PMF) on the Delaware River at the Hope Creek Plant. Use appropriate hydrologic models which input the 10 percent excedence high tide and the PMF hydrograph as the upstream input condition. b) Using the combined event criteria, provide your analysis of the water levels at the plant site associated with the seismic dam failure combined with the one-half PMF event on the entire river basin and the 10 percent excedence high tide at the plant site.

Response

Section 2.4.4 of the FSAR includes analyses of the effects of single and multiple dam failures on flood levels at the Hope Creek site. The analyses presented were based on the assumption that the previously proposed Tocks Island Dam would be built. A review of recent developments has lead us to the conclusion that the proposed Tocks Island Dam is no longer a viable project for the foreseeable future. Our conclusion is based on the following:

The Tocks Island Project was originally conceived in the early 1960s to provide flood control and water supply in the middle Delaware region. Funding was provided to the Army Corps of Engineers until 1975 for design, planning, land acquisition, and project review. In 1975, the Delaware River Basin Commission (DRBC) voted to ask Congress to stop funding the project and voted to put it on reserve status. In 1978, Congress passed PL 95-625 which included in the Wild and Scenic River System the section of the Delaware River that is bounded by the Delaware Water Gap National Recreation Area, much of which would have been inundated had the dam been built.

In 1983, the DRBC passed a resolution (No. 83-27) to amend its Comprehensive Plan to revise and update the description of the project. According to the resolution, the project has been placed in reserve for development if needed for water supply after the year 2000.

If the DRBC were to vote for development of Tocks Island at the turn of the century, Congress would have to reconsider the matter during the appropriation process and would also have to alter the designation of that section of the river under the Wild and Scenic River System. The considerable opposition to the project in the early 1970s would probably resurface to slow or halt Congressional action and the permitting process.

Based on the above, we have deleted consideration of the Tocks Island Dam in our analyses that follow.

The flooding effect caused by the Probable Maximum Flood and one-half Probable Maximum Flood were evaluated concurrently with the ten percent exceedence high tide level at the site using a one-dimensional backwater computer model (Reference 1). The dam flood analyses were evaluated following a one-dimensional flood wave routing procedure (Reference 2). The events are assured to be independent and therefore, the resulting flood depth caused by one-half PMF and dam failure flood represents the superposition of the independent events. The flood depth estimated for each event is referenced to the National Geodetic Vertical Datum (NGVD).

The magnitude of the Probable Maximum Flood, 1,250,000 cfs, represents the PMF for the entire drainage basin, an area of 12,765 square miles. This was estimated following the enveloping isoline technique described in Regulatory Guide 1.59 (Reference 3).

For the evaluation of PMF and one-half PMF, it was considered that the peak flood elevation occurs at the site location concurrent with the peak discharge based on gradually varied flow assumptions generally applicable to rierine flooding. Hence, a one-dimensional backwater profile model can be used. The cross sections were obtained using NOAA National Ocean Survey Nautical charts with soundings and elevations converted to NGVD (References 4 and 5). A total of seven cross sections were taken starting from the

Delaware Bay at Murderkill River to Reedy Point. A composite Manning's roughness coefficient value of 0.03 was used for the backwater profile model. Trail runs were made for both PMF and one-half PMF with starting water surface elevations equivalent to the ten percent exceedence high tide approximately 4.2 feet (NGVD), and Mean High Water at Murderkill River, 3.2 feet (NGVD).

For the evaluation of single dam failure flood, Francis E. Walter dam was considered while multiple dam failure considered seismically-induced failure of Pepaction Dam and Connonsville Dam instead of Tock's Island Dam. This procedure was also used for the preparation of the Safety Analysis Report. Starting with evaluating peak dam failure discharge and flood stage at the dam site the dam flood was then routed to the HCGS site. Variables used for the routing analysis include total flood release volume and valley storage index which represents the storage effect of the valley and the channel. Results give the attentuated peak discharge and flood stage which is referenced to the mean sea level.

For the estimation of the water flow velocity, the values of each contributing event was evaluated independently. Mean current velocities associated with the PMF and one-half PMF were calculated in the backwater profile model. Velocities associated with dam floods were estimated using simplified peak discharge, flow area calculation. To incorporate the wind effects the surface wind-induced current velocities are conservatively assumed to be approximately 5 percent of the 10-meter wind speed. Bretschneider (Reference 6) and Saylor (Reference 7) have concluded that 2 to 3% of the wind speed represents an average range of wind-induced currents speed. Further, the wind velocity in the surface friction layer above the water surface was estimated based on the 1/7th power law of the vertical wind velocity distribution. The thickness of the friction layer was assumed to be about 0.6 cm (Reference

6). The wave-induced horizontal orbital velocity was also calculated based on methods described in the Shore Protection Manual (Reference 8).

For the wind and wave-induced current computations, the wind condition used is the 2-year sustained extreme wind, approximately 50 mph in the study area.

Tables 1 and 2 present the results of the flood elevation and current velocity estimates. From this analysis, the flood elevation associated with PMF is approximately 7.6 ft (NGVD) concurrent with ten percent exceedence high tide. The multiple dam failure scenario results in a flood level of about 11.4 feet (NVGD) including one-half PMF and ten percent exceedence high tide which is approximately 1.0 feet above the plant grade, 10.5 feet (NVGD) at the service water intake structure. However, all flood elevations are below the plant grade of 12.5 feet (NGVD) at the Reactor Building. For a 2-year extreme wind speed of 50 mph, the wind speed in the surface friction layer can be as high as 25 feet per second. The average current velocity considering effects from multiple dam failure, with one half PMF, wind and wave induced effects is approximately 16 fps as estimated by superposition.

TABLE 1

WATER LEVEL ELEVATION ESTIMATES

EVENT	ELEVATIONS (NGVD) (feet)
1. Probable Maximum Flood with 10% exceedence high tide	7.6
2. One-half probable maximum flood with 10% exceedence high tide	5.4
3. Single dam tailing with one-half PMF and 10% exceedence high tide	10.4
4. Multiple dam tailing with one-half PMF and 10% exceedence high tide	11.4

TABLE 2

CURRENT VELOCITY ESTIMATE

EVENT	VELOCITY (fps)
1. Probable Maximum Flood	4
2. One-half Probable Maximum Flood	2
3. Single dam failure	4
4. Multiple dam failure	4
5. Wind-induced longshore current	4
6. Wave-induced surface horizontal orbital velocity	6
Velocity of Combined Events by Superposition	
1+5+6	14
2+4+5+6	16 (worst case)
2+3+5+6	16 (worst case)

REFERENCES FOR QUESTION 1

1. U.S. Army Corps of Engineers. The Hydrologic Engineering Center. September 1982. HEC-2 water surface profile corporate program.

2. Snyder, F.F., Hydrology of Spillway Design: Large Structures-Adequate Data. Journal of Hydraulics Division, Proceedings, ASCE HY3, May 1964.

3. U.S. Nuclear Regulatory Commission, August 1977., Regulatory Guide 1.59, Design Basis Floods for Nuclear Power Plants.

4. U.S. Dept. of Commerce, NOAA, NOS., Nautical Chart 12311, Delaware River, Smyra River to Wilmington, September 83 and Nautical Chart 12304, Delaware Bay, October 1983.

5. Mr. Milton Rustein, Chief, Tidal Datum Section. Personal Communication. Conversion of MLW level to MSLL MGVD, 1929 along Delaware River, January 3, 1985.

6. Bretschneidr, C.L., Storm Surges in Advances in Hydrosciences (Ed. V. T. Chow), Vol. 4, 1967. Academic Press, N.Y.

7. Saylor, J.H., Currents at Little Lake Harbor. Lake Superior, U.S. Lake Survey Res. Dep. No. H., Lake Survey District, U.S. Army Corps of Engineers, 1966.

8. U.S. Army Corps of Engineers, 1984. Shore Protection Manual, Vol. 1, prepared by Coastal Engineering Research Center, Dept. of the Army, Waterway Experimental Station.

Question 2

Discuss the impact of waterborne missiles, derived from upstream industrial areas as a result of these flooding events, on safety-related structures including the waterproof doors.

Response

The safety related structures of concern to the flooding generated missile analysis are the service water intakes structure and the doors on the power block. The service water intake structure is addressed in Question 3.

As far as waterborne missiles derived from upstream industrial areas are concerned, they are no threat to the waterproof doors on the power block since these missiles could not traverse the plant site. The answer to Question 1 indicates that the extreme water level due to flooding initiated from the north (upstream) results in a water level of 11.4 ft. above Mean Sea Level at the location of the plant. The water level is therefore about 1 ft. below plant grade and floating missiles could not enter the plant site and impact the power block doors.

Question 3

Discuss the ability of the service water intake structure to resist the impact of waterborne missiles (boats, barges, etc.) from upstream sources.

Response

To be provided later.

Question 4

Discuss the ability of exterior doors in safety-related structures to withstand the impact of a spectrum of waterborne missiles and identify the limit of the doors to resist the impact of the missile spectrum.

Response

As indicated in answer to Question 1, the worst postulated flood originating from the north (Question 1b) would lead to a water level of 11.4 ft. over Mean Sea Level in the vicinity of the Hope Creek Station. This water level is about 1 ft. below plant grade. As such, the power block doors are not exposed to missiles originating north of the plant.

The ADL Report analyzed the missiles which could impact the doors in the event of extreme wind event generated high water. As indicated in the ADL Report, very severe hurricanes on a highly specific trajectory could cause the water level to raise over plant grade allowing for the possible impact between waterborne missiles and the power block doors. The results of an impact analysis described in the ADL Report indicate that the doors will maintain leak-tightness for the full spectrum of missiles. The most severe impact results from a very large recreational boat (25,000 lbs.) impacting a door on a 10" round cross-section with a 20 mph velocity. This results in an impact energy per unit area of about 500,000 ft.-lbs. per ft^2.

Although for impact energies in excess of the above values, the leak tightness of certain doors could be compromised, the extreme conservations in the assumptions on the mass of the boat, cross-sectional area and impact velocity result in this case being one that bounds by a wide margin potential missiles that could reach safety-related structures on site.

Question 5

Provide the uncertainty associated with the extrapolation of an 11 year data base to represent return periods of up to 200 years, particularly in the development of a relationship between extreme wind speed and wind direction.

Response

To be provided later.

Question 6

Provide further justification of the use of the "Fisher-Tippett Type 2" distribution when other analyses of extreme winds (e.g., NUREG/CR-2639, "Historical Extreme Winds for the United States-Atlantic and Gulf of Mexico Coastlines") suggest use of a mixed distribution, with all type I distribution fitting non-tropical storms and the Weibull distribution fitting tropical storms.

Response

To be provided later.

Question 7

The statement is made on page 2 that "the particularly open exposure of this site is not adequately duplicated at any of the National Weather Service (NWS) stations in the region," implying that extreme wind speeds at the site may be higher than at the NWS stations. Provide a discussion of the exposure of NWS stations in the region, particularly at Wilmington, Delaware, and provide comparable estimates of extreme winds at the NWS stations for return periods of 20, 50, 100, and 200 years as in Table 2.

Response

To be provided later.

Question 8

Typically, extreme winds are represented by the fastest mile windspeed. Provide a comparison of fastest mile wind speeds for return pericds of 20, 50, 100, and 200 years between regional NWS stations and the site.

Response

To be provided later.

Question 9

Sustained winds with durations of 10 minutes are often examined to determine wave action, run-up and surges. Provide additional discussion and justification for use of 1 hour and 6 hour averages of wind speed for consideration of the effects of winds on riverborne missiles at Hope Creek.

Response

In the evaluation of the effects of hurricanes on riverborne missiles, five different storms were analyzed; PMH, model hurricane, and three other storms with maximum wind speeds between that of the PMH and the model hurricane. The maximum wind speeds used were by definition, the surface wind which is considered to be that which would be observed at 30 feet above the surface of the water whose speed is a 10 minute average. This parameter is part of the input to the computer program for computing surge on the open coast and routing up the Delaware Bay. The program considers the complete wind field associated with that maximum wind.

In calculating the open coast surge resulting from extreme wind events other than those accompanying hurricanes, we consider that the winds would have to be blowing for an extended period of time to obtain steady state conditions. We used maximum hourly wind speeds of 200, 100, 50, and 25 year recurrence intervals and assumed that they persisted undiminshed for six hours. A storm which would produce the maximum hourly wind would have associated with it a higher 10 minute wind speed. However, it would be the speed of longer duration that would develop the surge. Therefore, the surge values developed are conservative and reflect a wind field with somewhat higher 10 minute wind speed.

In calculating the effects of winds at the site, we assumed the localized wind conditions would result only in cross wind set-up or set-down. The time required to achieve this value is a function of wind speed, fetch and water depth. For 50 mph winds, it is on the order of one hour. Winds of hurricane force 140 mph would require 30 minutes. Therefore, our use of the one hour wind is appropriate.

Question 10

The attempt to quantify the probability of occurrence of a probable maximum hurricane (PMH) with a trajectory west of Artificial Island appears somewhat misguided, considering the deterministic deviation of the PMH parameters and the considerable uncertainties associated with hurricane trajectories prior to 1871. Provide additional discussion of the relationship of the PMH to trajectory, considering in particular the number of hurricanes which have or appear to have passed west of Artificial Island since 1683 (about six?) and that none of the observed hurricanes approached the intensity of the PMH.

Response

Please refer to the response to Question 21.

Question 11

The relationship between wind speed magnitude, direction, and duration appears crucial for this analysis. Although relationships between fastest mile wind speeds and sustained winds for 1 minute or 10 minute periods are available, the relationship between the direction of sustained winds is not well-established. Provide additional discussion of the relationship of extreme wind speeds to wind direction in the context of riverborne missiles at Hope Creek.

Response

In the MES study of the fastest-mile data for the 11 year period of site data, the six hour periods of maximum sustained winds in the direction sector of concern (79°-170°) was selected and then the fastest-mile wind peak occurring within that time period was determined. The fastest-mile wind was therefore within this same direction sector, although not pinpointed in the exact direction at the time of the fastest-mile occurrence. Since the fastest-mile data themselves have little to do with the development of the major surge, their specific directions are irrelevant, except possibly with respect to the movement of floating objects during the last few miles before reaching shore. Also, please see the response to question 9.

Question 12

Provide the details of your analysis performed to evaluate effects on power block structures and the intake structure due to the impact of the waterborne missile. These details should include, at least, the following:

a. Assumptions, Basis and Results.

b. Criteria used in evaluations.

c. Evaluation of local effects, including spalling of concrete on inside faces, potential impact on the safety-related equipments nearby, and leakage potential.

d. Overall effect of the waterborne missile on the structural elements and doors, and boundary mechanics by which the impact forces are transmitted from the door to the structure.

e. Overall stability of intake structure.

f. Any high frequency vibration effects on the attached equipment.

Response

a. The evaluation of the impact is based on the following:

   Assumptions:

- The types of missiles evaluated are described in the report "An Analysis of the Likelihood of Waterborne Traffic and Other Floating Objects on the Delaware River Impacting the Hope Creek Generating Station in Severe Storms" prepared by Arthur D. Little (ADL), Inc., September 1984.

- The impact phenomenon caused by the waterborne missiles on the structure is assumed to be similar to that of an automobile missile impacting on rigid target under a tornado event. As a result, the forcing function of the impact is assumed to be the same as that of an automobile impact, as described in Bechtel Topical Report BC-TOP-9A, "Design of Structures for Missile Impact," September 1974 (FSAR Reference No. 3.5-4).

- The nature of the impact is assumed to be plastic in which all of the missile momentum is transferred to the target.

Basis:

- Standard Review Plan, NUREG 0800, Section 3.5.3 is used as the basis of evaluation.

Results:

- Based on the missiles defined in the ADL Report, recreational boat type missile weighing 25 kips traveling at 20 mph is determined to be critical.

- Using extremely conservative assumption of rigid missile and the equivalent contact area of impact to be only 10 inches in diameter, the depth of perforation is estimated to be approximately 30 percent of the thickness of the thinnest wall (30 inches). Consequently, no adverse local damage is anticipated.

- In evaluating overall damage it is determined that the requirements of ductility ratios as described in Appendix A, Section 3.5.3 of NUREG 800 have been met. As a result, the overall structural integrity will not be adversely affected by the impact.

- Based on the above, it is concluded that the structure will remain leaktight following the postulated impact.

b. The criteria used for the evaluation are contained in the following references:

   o Hope Creek Generating Station Final Safety Analysis Report (FSAR), Docket No. 50-354.

   o USNRC Standard Review Plan, Section 3.5.3 of NUREG-0800.

c. Since the mass of the intake structure and the thickness of the exterior walls are considerably less than those of the power block, it is determined that evaluation of the intake structure will provide conservative results for concrete structural elements.

   The water depth associated with the unlikely, probable maximum hurricane event is expected to reach 40 ft. at the intake structure (ADL Report, page 8). At this water depth, the design missile is postulated to strike the structure at the western outside shear wall between elevation 100 ft. and elevation 128 ft. For the potential area of impact, this shear wall has a uniform concrete thickness of 30 inches.

   Perforation and spalling of the impacted shear wall are evaluated by using formulae for rigid missiles. The thickness required to prevent perforation is found to be approximately 10 in., which is substantially less than the wall thickness (30 in.). Since the design missile is a soft missile, the value obtained is very conservative. Based on the shape and the characteristics of the design missile, and the extremely conservative impact area used in the calculations, the spalling on the inside face of the impacted wall will not occur and, the leak tightness of the wall will be maintained after the impact.

   Since all safety related equipment is located inside the structure and away from the potential impact area, a direct hit by the design missile on the equipment is not possible. Furthermore, since spalling of the impacted concrete wall is unlikely, the impact of secondary missiles on the equipment need not be considered.

d. The calculated peak impact force is on the order of 4.6×10^5 lbs., and the required shear force to punch through the wall is 1.4×10^6 lbs. Since the punching shear force is more than twice the peak impact force, the concrete structural elements are determined to be capable of maintaining their integrity during and after the impact.

Evaluation on the leak tightness and the structural integrity of the door is given in ADL Report (page 20 and page 21). It is determined that all doors are capable of maintaining both the leak tightness and the structural integrity under the missile impact.

e. The peak impact force caused by the waterborne missile is only a small fraction of the total weight of the structures. Therefore, the stability of the Category I Structures will not be adversely affected by the postulated impact.

f. Using the conservative fundamental mode frequency of the fix base intake structure (13.5 Hz), the average acceleration level of the structure is found to be about 0.05g. The design SSE acceleration (0.2g) is significantly higher than the average global acceleration level of the structure. The maximum local acceleration level at the impact location, which is conservatively assumed to be at the center of the impacted wall, is found to be 1.50g. This acceleration will generally attenuate away from the impact location. For equipment which is located away from the impacted wall, the high frequency vibration effect presents no problem. For the traveling water screen, which is located closest to the impacted wall, the above two acceleration levels are still smaller than the design spectral value of 1.6g which corresponds to the Safe Shutdown Earthquake. Therefore, high frequency vibration effects caused by the waterborne missile do not result in a problem to safety related equipment located in the intake structure.

Question 13

For those structures and doors which may leak or fail or generate secondary missiles, provide the results of any analysis of the effects of the secondary missiles and flooding on safety-related systems and components. Credit for any mitigating action can only be taken for safety-related Class 1E powered structures, systems, and components.

Response

See response to Question 12c.

Question 14

On page 5 of the ADL Report, it is stated that grade level is approximately 14 ft. above Mean Low Water Level. In Table 2, footnote 4, page 7, it is stated that an increased water depth of 12 ft. over Mean Low Water results in a water level which is about 3 ft. below plant grade (rather than 2 ft., as would result from the statement on page 5 of the ADL Report). Is there a reason for the difference between the statements in page 5 and in Table 2?

Response

The elevation and water height numbers in the ADL Report are approximate to within about 1 foot. This approximation does not compromise the analysis or change any conclusion. The most recent measures of datum and water level relationships are contained in Figures 2.4-3 of the Hope Creek Final Safety Analysis Report. A copy of Figure 2.4-3 dated October 1983 is attached.

It can be seen from this figure that plant grade is actually 15.1 ft. above Mean Low Water. Under the postulated extreme wind scenario the water level could rise up to 12 ft. over Mean Low Water. In this case, the water level would still be about 3 ft. below plant grade.

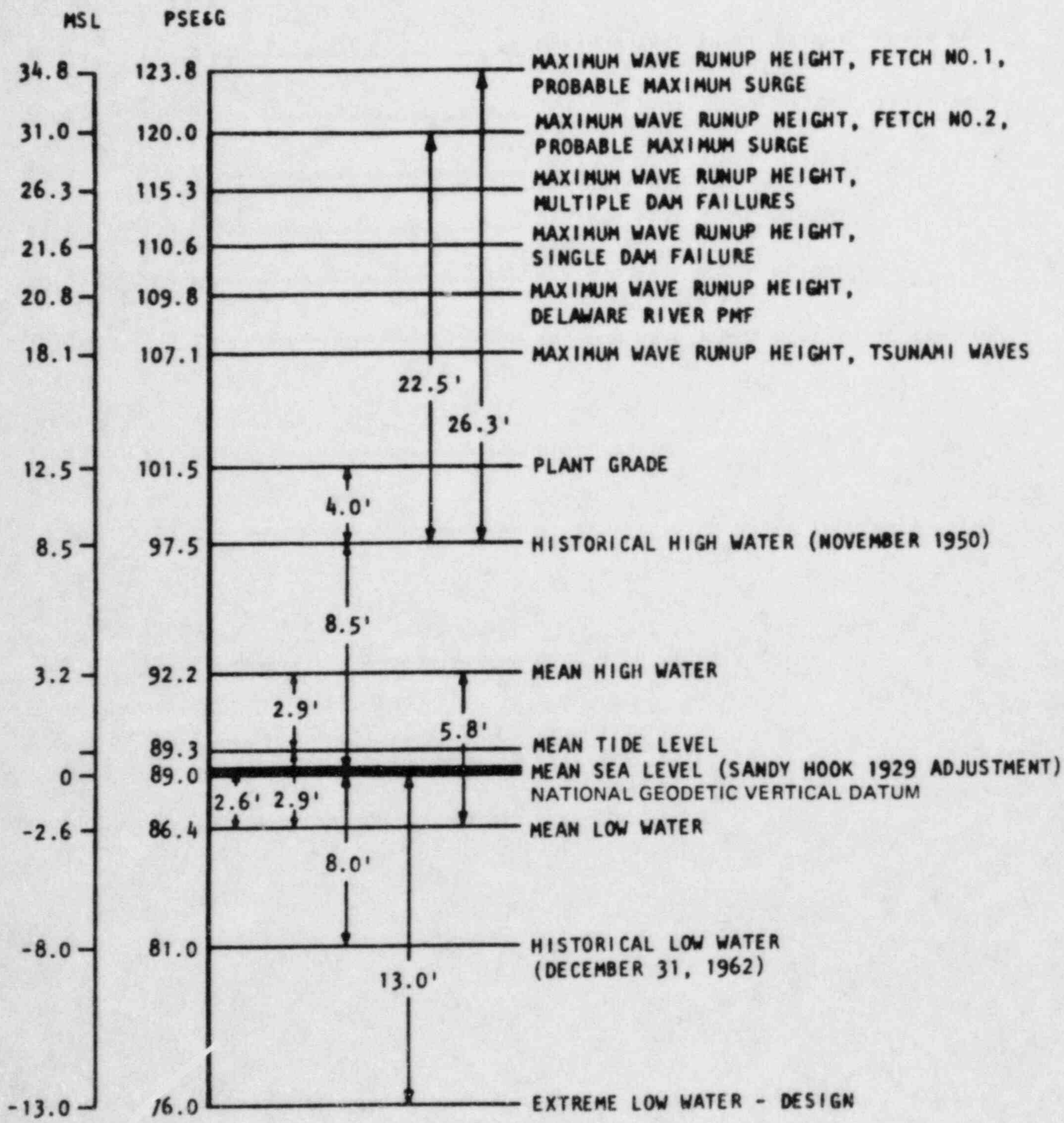
Question 15

It appears implicit in the estimate of the kinetic energy per unit area for a large recreational boat hitting a structure (page 16) that the impact area is 100 ft^2. Explain why the impact areas could not be significantly smaller than 100 ft^2.

Response

The discussion on page 16 is presented only as a hypothetical example. In order for a 10 ton recreational boat to impact a rigid concrete structure and not sustain damage to itself (so as to look at the worst-case damage to the intake structure) a structurally strong segment of the recreational boat would have to be the impact point. Such a strong segment is unlikely to exist on a recreational boat, but if it did, it may likely have the 100 ft^2 surface area.

However, the discussion on page 16 is only a general narrative of a postulated scenario. The actual values used for the impact area in the door integrity analysis was about 1



HOPE CREEK GENERATING STATION
FINAL SAFETY ANALYSIS REPORT

DATUM AND WATER LEVEL RELATIONSHIP

FIGURE 2.4-3 AMENDMENT 2, 10/83

ft^2 as represented by a 10" round cross-section discussed on page 19 of the ADL Report. Also, a very large recreational boat weighing 25,000 lbs. was considered in the analysis (see page 19 of the ADL Report). Both the size and impact are conservative in that they result in a very large energy per unit area being transmitted to the doors.

Question 16

Explain why the chances of an unmanned vessel approaching within 10 miles of Hope Creek without a prior grounding are estimated on page 44, Appendix C of the ADL Report, to be less than 10 percent?

Response

The unmanned vessels which could break free from a barge tow in the highly unlikely event of a barge tow being anchored on the Delaware substantially south of Artificial Island in an extreme wind event would be a barge. Of the three major types of barges, an open top hopper barge with its two to three feet freeboard would probably sink within a few minutes under the postulated extreme wind and water conditions. A closed top sea-going barge or a liquid cargo barge could survive longer provided it is not punctured due to impact with other floating objects (debris) which would be present in the river during the postulated storms. However, because of surface currents and wind driven "sail area" effects, the barge would be pushed towards the banks of the river where it will ground in the shallows prior to substantial movement towards the plant. Subsequent to grounding, it would be impacted by floating debris and could sink. The barge could also undergo some additional movement, but we do not consider this likely. Based on the above unmanned vessel movement scenario, it was assumed that the likelihood of such a vessel approaching a location within 10 miles south of the plant prior to sinking or grounding was less than 10 percent.

Question 17

It is assumed in the ADL Report (page 45) that the probability per mile of simultaneous loss of power and steering is $\lambda = 10^{-5}$/mile. This estimate is based on historical data contained in References 1 and 7. Do these historical data pertain to severe storm conditions? If not, are the estimates independent of whether storm conditions are present?

Response

The United States Coast Guard is required by law to investigate all marine casualties in U.S. waters and any maritime casualty world-wide involving a U.S. vessel of any kind. This law requires a report from the owner, master, agent, a person involved in a casualty that resulted in damage in excess of $1,500, material damage affecting the seaworthiness of efficiency of a vessel, grounding, loss of life, or an injury which incapacitates for more than 72 hours (46 CFR 4.05-1). The segment of the data contained in the Coast Guard files which deals with loss of power and steering for self-propelled vessels is for all weather conditions. We have assumed that the estimate $\lambda = 10^{-5}$/mile obtained from the Coast Guard data base is valid for all weather conditions and would not increase in severe storms. The reason for this is as follows. The sub-surface currents and wind drag encountered by a vessel during a severe storm would be somewhat larger than under more "normal" deep sea storm circumstances for which the vessels are designed, but the stress on the power screws and the rudder (both under the water level) would be so excessive as to cause failure. The degree of maneuverability available in terms of actual headway possible in the desired direction may be diminished but would not lead to loss of both power and steering. As such, we believe that a value for λ of 10^{-5}/mile is appropriate.

Question 18

Explain why, once power and steering are lost, the vessel is more likely to head towards the target (rather thn equally likely to move in any direction), by a factor of about 10 for the water intake structure and by a factor of about 100 for entering the Hope Creek site (see page 47 of the ADL Report).

Response

In order to achieve the extraordinarily high water levels associated with the various hurricanes, the postulated scenarios require that the hurricane follow a highly specific track. The actual wind and current driven effects on a marine vessel would depend on the relative location of the vessel with respect to the "eye" or the center of the hurricane. A drifting marine vessel generally would move in a northern direction with the wind and current, but could also drift in an easterly or westerly direction. Movement in a southerly direction is not possible under the postulated scenario.

The above situation was modeled analytically utilizing the appropriate probability distribution for wind and tracking of the vessel movement on a half-mile basis once the vessel was at a location within 10 miles south of the plant. Based on this, and the target size presented by the plant (120 ft. for the intake structure and 1500 ft. for the onsite safety-related structures), it was found that a drifting vessel was more likely to move towards the plant than if the wind direction was uniformly distributed over 360°. This resulted in a greater likelihood factor of 10 for the water intake structure and about 100 for the Hope Creek site area of concern.

Question 19

The probabilities of strike by a non-self-propelled vessel already within 10 miles of Hope Creek striking the water intake structure are stated on page 48 of the ADL Report to be 1.2×10^{-5}/vessel for the intake structure and 3.1×10^{-3}/vessel for the Hope Creek site. Were the same multiplication factors of 10 and 100 used in these estimates as the estimates discussed in item 5 above?

Response

Yes. Refer to the answer to Question 18 for details.

Question 20

In any given storm, wind speeds over water are higher than wind speeds over ground. It appears this was not taken into account in the estimate of annual probabilities of extreme six hour wind speeds at 33 ft. elevation. Is this the case? If so, why?

Response

To be provided later.

Question 21

In the July 1984 MES Report it is stated that the probability of occurrence in any one year of a "probable maximum hurricane," H(max), having a direction of motion D, capable of causing a very large tidal surge can be obtained as follows:

$$P(H(max),D) = P(H(max)) P(D) \quad (1)$$

where P(H(max)) = probability of occurrence in any one year of a probable maximum hurricane regardless of trajectory, and P(D) - probability of occurrence in any one year of a storm having the direction of motion D. It is estimated in the above-mentioned Report that P(H(max)) approximately equals 1000 per year. It is further estimated in the Report that P(D) approximately equals 100 per year, the justification for that estimate being that only one storm in 100 years was sufficiently strong and had the direction of motion needed to cause a significant tidal surge.

Actually, P(D) should represent the ratio of the number of storms having a direction of motion D to the total number of storms, regardless of their direction. For the area and time frame considered, it would follow from the report that this ratio is above 5/39 (page 9). If the ratio 5/39 were used in equation 1 above, rather than the ratio 1/100, the estimated probability P(H(max), D) would increase by an order of magnitude, i.e., it would be about 10E-4 per year, rather than 10E-5 per year as estimated in the MES Report.

To summarize, it appears that the MES Report uses, in lieu of P(D), a joint probability P(V,D), where V is a relatively large wind speed such that P(V,D) approximately equal to 100 per year. An explanation is requested concerning this matter.

Response

The NOAA document on the Standard Project Hurricane and the Possible Maximum Hurricane (PB80-117997) provides results that are deterministic in the sense that each of the hurricane parameters has been established as being possible for the latitude and the coastline of concern. However, this report only sets limits to the values that might be encountered without providing any indication of the probability of occurrence. For example, for Milepost 2400, the entrance to Delaware Bay, the report shows that the forward speed might range from 40-80 km/hr (Fig. 2.7) and the angle of approach could fall between 70° and 185° (Fig. 2.9), but there is no indication what probability might be associated with either of these ranges, or more important, what their joint probability might be.

Furthermore, as pointed out in our earlier submittal on this subject, the authors of the PSH-PMH documents discourage the reader from attempting to establish a probability for any of the individual parameters, much less a probability for the combination of the various factors.

For this reason, the original hurricane trajectory and intensity data was used in order to try to establish a reasonable probability of having the PHM affect the Hope Creek site in such a way as to cause the highest possible surge. In that analysis, close attention was paid to the full trajectories of the storms, not merely the angle of attack and forward speed as they approached the coast. To achieve the maximum effect, the storm could not pass over land for any considerable distance prior to reaching the site. Neither could it follow any path to the east of the site or one more than a few miles to the west of the site. It was concluded that seven storms passed within 100 miles west of the site between 1871 and 1983, but only one of these actually followed a trajectory that would keep it over water until reaching the immediate site area (MES Report, 7/6/84, page 8). In the earlier period analyzed, from 1683 to 1869, it appears that five storms passed close enough to the west of the site to produce reportable storm surges, but only one seems to have resulted in a major flooding of the area (ibid. page 9).

A hurricane would have to follow a trajectory taking it past the site within approximately a 10 mile band to be included in an analysis of the probability of having the PMH cause a major surge in the area.

Based on our assessment, we conclude that the probability of the PMH surge is a combination of having the PMH aggregation of parameters occur simultaneously (10^{-4}) times the probability that the storm would approach the coast on precisely the right trajectory and pass just west of the site (two cases in 300 years, or $<10^{-2}$). The 5/39 ratio cited in question 21 is certainly not applicable, nor would it be proper to use seven over the total number of hurricanes observed in the 1871-1983 period.

Question 22

It is stated in the August 1984 MES Report (page 4) that the NBS BSS-124 document "is based on actual hurricane climatology and statistics only insofar as the frequency of occurrence of hurricanes in various locations is concerned." Actually, NBS BSS-124 also uses statistics based on climatological data concerning the pressure difference between center and periphery of storms, radius of maximum wind speeds, speed of translation of storm, and direction of storm translation (see pages 3 and 4 of NBS BSS-12). The MES Report should be corrected to reflect this information.

Response

NBS-124 was based in part on climatology other than just the frequency of occurrence. However, the misstatement has no effect on the utilization of the data in the report, nor does it have any bearing on the new estimates of fastest-mile and longer-period wind data.

Question 23

In Table 1 of the August 1984 MES Report, were any of the storms of the thunderstorm type? This question is asked because if indeed some of those storms were of that type, then the ratios, FM/1H and FM/6H, would be too high to be possibly representative of hurricane winds."

Response

The events listed in Table 1 of the August MES Report are the dates of the maximum annual six hour wind speed averages for each of the 11 years of record. These events do not necessarily contain the overall maximum fastest-mile wind speeds for each of these 11 years, and it is probable that some of the absolute fastest-mile observations may have been associated with thunderstorms.

However, review of the synoptic situations for each of the time periods used in the analysis indicated that in all cases the strong onshore winds were caused either by deep winter-type low pressure systems located west of the site, or a combination of strong high pressure to the east and low pressure to the west. These situations indicate strong winds persisting for time periods on the order of hours, not minutes as is common with thunderstorms, and there was no indication that thunderstorms contributed to any of the fastest-mile data.

Therefore, the ratios of fastest-mile wind speeds to longer-term averages quoted in the MES Report are representative of larger scale storms. The method of using peak/average ratios based upon non-tropical storms to simulate hurricane situations is recommended on page 10 of the NBS-124 document.

Question 24

Page 7 of the August 1984 MES Report reproduces estimates of directional fastest-mile wind speeds from the NBS BSS-124 Report. However, the estimates of NBS BSS-124 pertains to winds blowing from a 360°/16 = 22.5° sector, rather than from the 79°-170° sector. Using data on which the NBS BSS-124 Report is based (which are available on tape at NBS), the fastest-mile wind speeds at 33 feet over ground is estimated as 36 mph, 73 mph, and 85 mph for the 10, 50, and 100 year means recurrence intervals, respectively, rather than 24 mph, 57 mph, and 70 mph, as indicated on page 7 of the August 1984 MES Report.

Response

To be provided later.

Question 25

Page 4 of the Arthur D. Little, Inc. report, "An Analysis of the Likelihood of Waterborne Traffic and Other Floating Objects on the Delaware River Impacting the Hope Creek Generating Station in Severe Storms" revised report dated September 1984, lists a number of floating objects such as utility poles, houses, automobiles, fuel tanks, and trees which were analyzed for potential damage to metal doors in the power block. In view of the location of rail lines and chemical industries at relatively low grade elevations upstream from the reactor site, indicate if empty railroad tank cars and industrial chemical storage and/or processing tanks should also be included in the flood missile spectrum. Indicate the size (and mass) of these tanks as compared with the size of the power block doors and hatches.

Response

As indicated in answer to Question 1, the highest water levels associated with flooding events initiated from the north are those associated with the seismic multiple dam failure combined with the one-half PMF event on the entire river basin and the 10 percent excedence high tide at the plant site. This event leads to a site water level of 11.4 ft. above Mean Sea Level. Under these conditions, the water level would be about 1 ft. below plant grade. As such, any waterborne missile generated north of the plant could not exist on plant grade and could not impact the power block doors and hatches.