UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
GEORGIA POWER COMPANY, et al.	)	Docket Nos. 50-424
	)	50-425
(Vogtle Electric Generating Plant, Units 1 and 2)	)	

AFFIDAVIT OF DANIEL H. WARREN

COUNTY OF JEFFERSON)
)
STATE OF ALABAMA)

I, Daniel H. Warren, being duly sworn according to law, depose and say as follows:

1. My name is Daniel H. Warren. I am employed by Southern Company Services, Inc. in the position of Environmental Licensing Engineer. My business address is Southern Company Services, Inc., P.O. Box 2625, Birmingham, Alabama 35202. Attached to this affidavit as Exhibit A is a summary of my professional qualifications.

2. The purpose of this affidavit is to support Applicants' Motion for Summary Disposition of Joint Intervenors' Contention 12, which concerns salt and chlorine gas emitted from the natural draft cooling towers at the Vogtle Electric Generating Plant ("VEGP") as part of the drift from those towers.

3. In this affidavit I will describe the operation of the natural draft cooling towers, the manner in which chlorine is added to the water in the towers, and the different estimates made by the Applicants of the expected drift deposition rates for the VEGP cooling towers. I have personal knowledge of the matters set forth herein and believe them to be true and correct.

I. The Principles of Operation of the Plant Vogtle Natural Draft Cooling Towers.

4. Units 1 and 2 of the VEGP are each equipped with a natural draft cooling tower. Each tower consists of five main components: (1) the basin, which catches and stores the cooled water; (2) the fill, which consists of tiers of cement sheets that act as a heat transfer surface where warm water and cooling air come into contact; (3) the warm water distribution system, which distributes the warm water evenly over the entire fill; (4) the drift eliminators, which reduce the quantity of the water droplets entrained in the air discharged out of the top of tower; and (5) the hyperbolically shaped chimney or veil, which creates the draft necessary for tower operation.

5. Figure 12-8 provides a general diagram of a natural draft cooling tower like the ones at VEGP showing its major components and briefly describes the mechanics of its operation.

6. The purpose of the natural draft cooling towers at VEGP is to cool the warm water entering the towers to a lower temperature so that it can be recycled through the condenser. The cooling towers perform their function by exposing the warm water to cool ambient air in such a way that heat is transferred from the warm water to the cooler air through both latent heat transfer and sensible heat transfer.

7. Upon exposure to cool air, hot water evaporates, and the evaporation process consumes approximately 1000 BTUs per pound of water evaporated. This heat is drawn from the water remaining after evaporation, thereby lowering its temperature. This transfer of latent heat accounts for approximately 75% of the heat transfer that occurs. The remaining heat transfer results from sensible heat exchange. When two masses having different temperatures come into contact, heat is exchanged and the temperatures of the two masses approach an equilibrium. When warm water contacts cool air during the operation of a natural draft cooling tower, the air receives sensible heat from the water and is warmed, while the water loses sensible heat and is cooled.

8. The natural draft cooling towers at VEGP are designed to increase the interface between the warm water and the cooler ambient air to maximize the occurrence of latent heat transfer and sensible heat transfer. The warm

water distribution system transports the hot water from the condenser to the top of the fill and distributes it evenly over the entire fill. The tiers of cement sheets that comprise the fill break up the water into thin films, maximizing both the surface area of the water exposed to air and the resulting evaporation.

9. As the warm water runs down the fill sheets and falls to the cold water basin below, it comes into contact with ambient air. As that air is warmed, it becomes lighter, and the resulting difference in the specific weights of the air inside and outside the tower causes the natural draft through the tower. Thus the water falling on the fill comes into contact with and is opposed by the counterflow of air up through the fill.

10. The warmed, moist air moving upward as a result of the natural draft then passes through the drift eliminators. Composed of panels containing wave-shaped passages, the drift eliminators reduce the amount of water droplets leaving the tower with the warmed air. By causing the rising air to change direction, the drift eliminators collect many of the water droplets carried by the air. The warm air is then discharged out of the top of the towers into the atmosphere, and the cooled water, including the water droplets collected on the drift eliminators, falls to the basin where it is recycled.

11. Because the drift eliminators do not collect all of the water droplets entrained in the warm air rising out of the tower, some water droplets are carried by that warm air out of the tower. These water droplets are commonly referred to as the "drift" from the cooling tower. These droplets that exit the cooling tower contain the same dissolved solids as the water circulating in the tower. Those dissolved solids are dispersed into the area surrounding the tower when the droplets either fall to the ground or evaporate. The dispersed dissolved solids are commonly referred to as the "salt drift" from the cooling tower, although only some of those dissolved solids are salts.

II. The Manner in Which Chlorine Will Be Added to the Water Found in the Natural Draft Cooling Towers.

12. At VEGP chlorine will be added to the water that ultimately reaches the natural draft cooling towers at two different points. Makeup water drawn from the Savannah River will have chlorine gas injected into it by the river water chlorination system, which has two 6000 pound per day chlorinators, one of which will be used as a backup. That system will normally operate only during Corbicula spawning season, when it will operate continuously for five days each month. The amount of chlorine injected will vary depending upon the chlorine demand exerted by

the makeup water. Sufficient chlorine will be injected to maintain a free available chlorine concentration of 1 mg/liter at the discharge of the makeup pumps up to a maximum intended dosage of 10 mg/liter chlorine.

13. The second point at which chlorine gas will be injected is the circulating water chlorination system. That system has three 10,000 pound per day chlorinators, one of which will be used as a backup. The amount of chlorine added to the circulating water by that system will vary depending upon the rate of biological growth and the chlorine demand present in the circulating water system. Intermittent chlorination necessary to produce an average concentration of 0.2 mg/liter free available chlorine in the circulating water condenser discharge will be used, with the maximum concentration being 0.5 mg/liter. Because of increased biological growth on warm days, chlorine will be injected from one to three times per day during the summer, while only a single weekly injection period should be required during the winter when biological growth activity is low.

14. During Corbicula spawning season, the circulating water chlorination system will operate continuously up to five days per month at a level sufficient to maintain a free available chlorine concentration of 1 mg/liter. During the remainder of the month during Corbicula spawning

season, the circulating water system will be chlorinated as described above in paragraph 13.

III. The Applicants' Estimates of Drift from the VEGP Natural Draft Cooling Towers.

A. The Applicants' Estimate at the Construction Permit Stage.

15. The Applicants initially estimated the drift deposition rate for the VEGP natural draft cooling towers at the construction permit stage in the early 1970's. At that time computerized models of cooling tower drift based upon site specific conditions were not widely used and analyses of drift were not very sophisticated. By simply calculating a drift emission rate and dividing the total amount of drift emitted in a one year period by the amount of land surface within a one mile radius of the towers, the Applicants derived an estimated annual drift rate of 305 pounds per acre per year for two towers. Construction Permit Stage Environmental Report ("CP-ER"), § 5.3.2. The Applicants based that initial drift deposition rate estimate, however, upon several unrealistic assumptions that caused it to be far too conservative.

16. First, in calculating that estimate, the Applicants assumed that all of the dissolved solids contained in the drift would be deposited in an area within a one mile radius of the cooling towers. Even at the construction permit stage, the NRC staff concluded that this

assumption was unrealistic, citing analyses done at other locations that showed drift deposition occurring two to three miles from cooling towers. Construction Permit Stage Final Environmental Statement ("CP-FES"), § 5.5.1.1.

17. Second, the Applicants used a drift rate of 0.03% in deriving that initial estimate, which rate corresponded to the drift rate guaranteed in the contract between Georgia Power Company and Custodis-Cottrell (formerly Research-Cottrell), the tower supplier. The guaranteed drift rate is a contractually established maximum drift rate that does not correspond to the drift rate actually expected to occur. At the time it submitted its proposal for construction of the cooling towers to Georgia Power in 1973, Custodis-Cottrell identified the drift rate that would be expected during tower operation as 0.015%. In 1984, Custodis-Cottrell orally advised the Applicants that subsequent testing and technical analysis caused it to expect the drift rate for a tower of the design used at VEGP to be 0.008%. More recently, however, Custodis-Cottrell has advised the Applicants that it would expect that the drift rate for natural draft cooling towers with drift eliminators of the same design as those at VEGP would be 0.004% or less. In fact, for the natural draft cooling towers at Georgia Power's Plant Scherer, which towers have drift eliminators that are essentially identical to Plant Vogtle's, the contract with Custodis-Cottrell

nets a guaranteed drift rate of 0.008% and an expected drift rate of 0.004%. Despite Custodis-Cottrell's reduction in what it would expect the drift rate to be for the VEGP natural draft cooling towers to 0.004% or less, the Applicants have continued to use the more conservative rate of 0.008% in estimating drift deposition rates for the VEGP cooling towers.

18. In addition to these unrealistic assumptions, other factors caused the Applicants' initial estimate to overstate significantly the drift deposition rate. In calculating the total dissolved solids present in the water from the Savannah River, the Applicants used the maximum level found in sampling programs, which was 76 mg/liter, rather than the average level of 60 mg/liter. Also, the Applicants assumed that the cooling towers would be operated at eight cycles of concentration rather than the expected average operating rate of four cycles of concentration.

19. For these reasons, the drift deposition rate calculated by the Applicants at the construction permit stage was unrealistically conservative. The Applicants did not at that time undertake a more detailed analysis of the cooling tower drift because the deposition rate they initially predicted met, in light of the amount of rainfall in the area, the then existing irrigation and livestock water supply guidelines. CP-ER § 5.3.2.

B. The Applicants' Revised Estimates of Drift Deposition Developed Using a Bounding Technique.

20. Because no changes had occurred since the construction permit stage that would increase the drift deposition rate, the Applicants did not do any further calculations of the drift deposition rates when they submitted the Operating License Stage Environmental Report (OL-ER") in the fall of 1983. The NRC staff, however, noted that a deposition rate of 305 pounds per acre per year was considered to be in the range that could potentially cause damage to vegetation and asked the Applicants to reassess salt drift deposition due to cooling tower drift. OL-ER, Questions E290.3 and E451.17.

21. In response, the Applicants noted the very conservative assumptions underlying their initial salt drift deposition estimates and submitted new estimates, determined using a different methodology, of 31 pounds per acre per year and 21 pounds per acre per year for the maximum on-site and off-site peak deposition rates. OL-ER, Response to NRC Question E451.17. In response to a subsequent question from the NRC staff concerning the calculation of these new estimated on-site and off-site deposition rates, the Applicants further revised those estimates to a maximum on-site rate of 17 pounds per acre per year and an off-site rate of 15 pounds per acre per year. OL-ER, Response to NRC Question E290.8. As explained in

greater detail in paragraphs 3 through 11 of the Affidavit of Nora A. Blum, the Applicants derived these new estimates not by actually modeling the performance of the VEGP cooling towers, but by predicting maximum drift deposition rates for VEGP based upon extrapolation to VEGP conditions of drift deposition rates estimated using models by other plants having similar cooling towers and meteorological conditions. This methodology was not intended to predict accurately for all conditions the exact drift deposition rates that will be experienced by the VEGP cooling towers. Instead, the Applicants sought to derive an estimate that would very likely exceed, and therefore provide an upper bound for, the maximum deposition rates that would be experienced at VEGP.

C. Use of the NUS FOG Model to Predict Salt Drift Deposition Rates for VEGP.

22. In the fall of 1984, the Applicants retained NUS Corporation to conduct a modeling study of the drift deposition rates that would actually be experienced by the VEGP natural draft cooling towers. The results of that study demonstrate that the Applicants' prior drift deposition estimates were very conservative and that the amount of salt drift from the VEGP natural draft cooling towers will be insignificant.

23. The NUS Corporation's FOG model, the VEGP specific data used in running the model, and the results of

the modeling study are described in greater detail in the Affidavit of Dr. Morton I. Goldman. Using a conservative analysis, the NUS Corporation's FOG model predicted a maximum off-site drift deposition rate of less than three pounds per acre per year (including the additions due to chlorination) resulting from the operation of the VEGP natural draft cooling towers.

24. Prior to the modeling study performed by NUS Corporation, none of the techniques used by the Applicants to estimate salt drift deposition rates involved modeling based upon extensive site-specific data concerning meteorological conditions and cooling tower operating characteristics. For that reason, the Applicants consider their prior estimates of salt drift deposition to be overly conservative and consider the results of the NUS modeling study to be much more appropriate estimates of the drift deposition rates that will occur at VEGP.

David H. Warren
Daniel H. Warren

Sworn to and subscribed
before me this 8th day
of July, 1985.

Sylvia R. O'Berry
Notary Public
My commission expires 4/12/87

Evaporative cooling, a simple four-step process

FIGURE 12-8

Entry Water is pumped into the tower at the **Warm Water Inlet,** and is pumped upward through the concrete **Warm Water Risers.**

Distribution The water is fed into a network of **Warm Water Distribution** pipes, which are evenly spaced throughout the interior of the tower. The flow from these pipes is sent downward through a system of nozzles and specially designed splash plates which spray the water to form a thin film over the heat exchanger surfaces.

Evaporative Cooling As the hot water flows downward, it is met by dry air rising upward through the fill; at this contact, evaporative cooling takes place. This cool, dry air has entered the tower through the **Air Inlet** which completely encircles the base of the tower. The density differential created between the warm air in the tower and the colder ambient air causes the flow of warm air upward in the tower, resulting in the natural draft, or chimney effect, throughout the tower.

Cool Water Recycled The cooled water falls into the **Water Basin** formed by the floor of the tower, where it is returned to the condenser for the entire cycle to begin again.

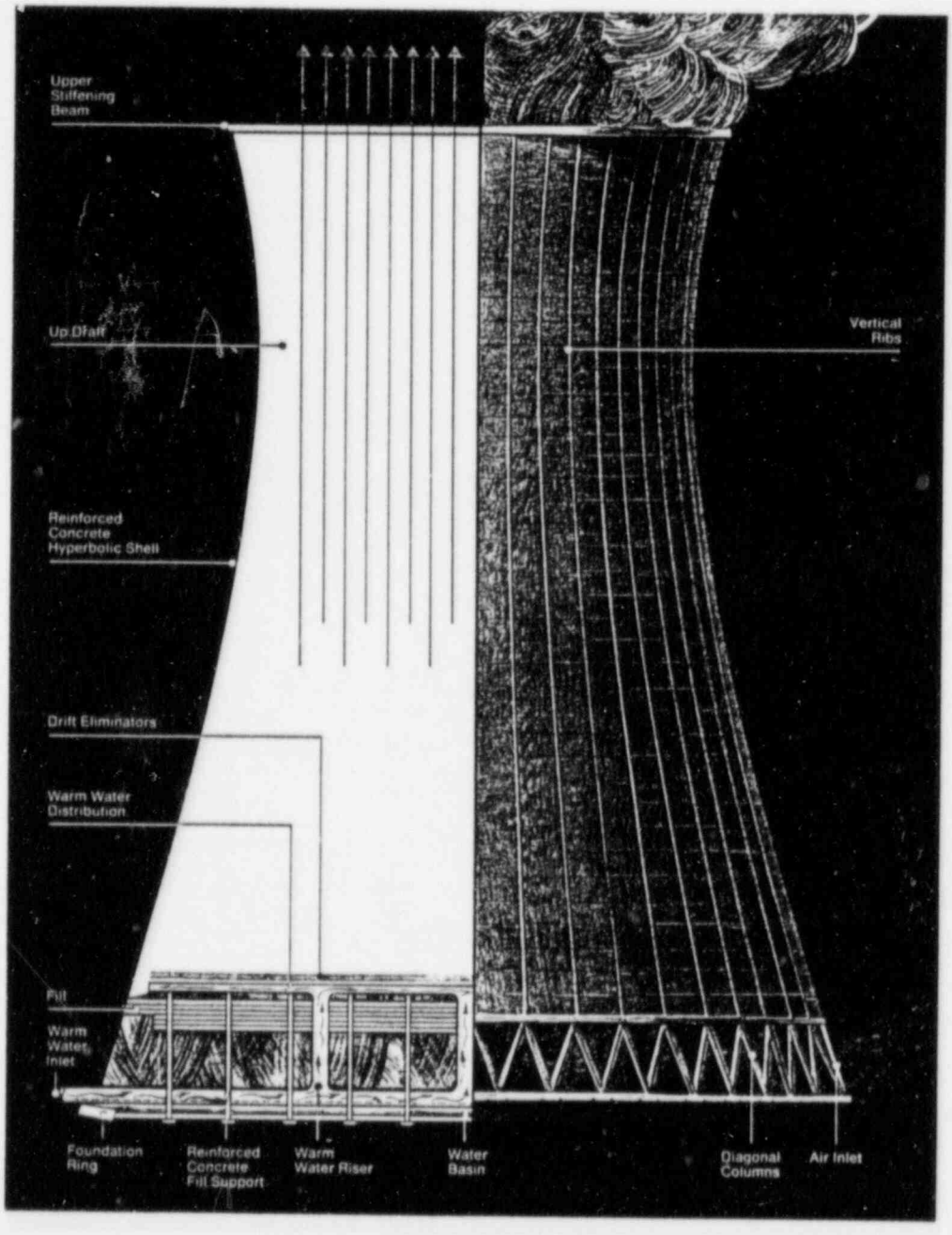

Exhibit A

Summary of Professional Qualifications

Daniel H. Warren
Environmental Licensing Engineer
Southern Company Services, Inc.

I graduated from Auburn University in December 1978 with a B.S. degree in biological sciences. I subsequently attended Clemson University and received a M.S. in Environmental Systems Engineering in May 1982. My graduate degree emphasized environmental management with my research focused on geomorphology and surface water hydrology. I joined Southern Company Services, Inc. in June 1982 as an Environmental Licensing Engineer. I have performed work ranging from environmental regulation of wastes to nuclear environmental licensing. My work experience includes coordinating and participating in the writing, reviewing, and submission of the Operating License Stage Environmental Report for the Vogtle Electric Generating Plant in support of the operating license application. This involved becoming familiar with the following Vogtle site specific areas: geography and demography, ecology, meteorology, hydrology, geology, historic features, plant features, aesthetic effects, radiological and nonradiological waste systems and their environmental effects, heat dissipation systems, plant water use, preoperational and operational monitoring programs (both radiological and nonradiological), environmental effects of accidents, social and economic effects, and various permits, certifications and approvals associated with operation of the plant and transmission systems. I have coordinated the reveiw of and participated in commenting on the NRC staff's Draft Environmental Statement related to the operation of Plant Vogtle.

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	:	

CERTIFICATE OF SERVICE

I hereby certify that copies of the Affidavit of Daniel H. Warren, dated July 8, 1985, were served upon those persons on the attached Service List by deposit in the United States mail, postage prepaid, or where indicated by an asterisk (*) by hand delivery, this 11th day of July, 1985.

James E. Joiner
Attorney for Applicants

Dated: July 11, 1985

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GEORGIA POWER COMPANY, et al.	)	Docket Nos. 50-424
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(Vogtle Electric Generating Plant, Units 1 and 2)	)	

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