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 OL
	)	50-425 OL
(Vogtle Electric Generating Plant, Units 1 and 2)	)	

AFFIDAVIT OF MORTON I. GOLDMAN

COUNTY OF MONTGOMERY)
)
STATE OF MARYLAND)

I, Morton I. Goldman, being duly sworn according to law, depose and say as follows:

1. My name is Morton I. Goldman. I am employed by NUS Corporation in the position of Senior Vice President and Technical Director. My business address is NUS Corporation, 910 Clopper Road, Gaithersburg, Maryland 20878.

2. The purpose of this affidavit is to support the 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. In this affidavit, I will

describe a study performed by NUS Corporation modeling the drift deposition from the VEGP cooling towers and will discuss the additions to the total dissolved solids in the cooling tower drift resulting from the chlorination of the water circulated through the cooling towers. I have personal knowledge of the matters set forth herein and believe them to be true and correct.

3. I graduated from New York University in 1948 with a B.S. degree in Civil Engineering. I subsequently attended the Massachusetts Institute of Technology and received the following additional degrees: in 1950 an M.S. degree in Sanitary Engineering, in 1958 an M.S. in Nuclear Engineering, and in 1960 an Sc. D.

4. I am a registered professional engineer in New York (1955), the District of Columbia (1965), Maryland (1972), Arizona (1974), California (1977), and South Carolina (1982). I am a member of the American Society of Civil Engineers, the American Nuclear Society, and the American Academy of Environmental Engineering.

5. Since my employment by NUS Corporation in 1961, I have held a series of positions from Technical Associate to Senior Vice President, Environmental Systems Group. I have performed and managed work in safety and environmental areas, including site selection and evaluation; safety analysis for commercial, military, and aero-space nuclear

applications; waste management systems evaluations; environmental assessments; and impact analyses for nuclear and fossil fueled electric generating plants and industrial facilities. In my current position as Senior Vice President and Technical Director of NUS Corporation, I have responsibility for auditing and guiding NUS Corporation's technical capabilities, serving as senior corporate spokesman on environmental and nuclear safety issues, and providing senior level consulting and project direction for different clients of NUS Corporation.

6. Prior to being employed by NUS Corporation, I served eleven years with the U.S. Public Health Service, Division of Radiological Health. While with the Public Health Service I worked on a variety of assignments, including serving as a training instructor, conducting research on disposal of radioactive wastes at Oak Ridge National Laboratories and at Massachusetts Institute of Technology, participating in a working group responsible for radioactivity standards in the 1960 Public Health Service Drinking Water Standards, and providing technical consultation and assistance to state and federal agencies on health and safety problems of nuclear facilities.

7. I have testified as an expert witness in a variety of proceedings. Between 1972 and 1975, I served as a consultant to and expert witness for the Consolidated Utility Group in the AEC/NRC rule-making proceeding on "as

low as practicable" radioactive waste discharge standards, and from 1975 to 1977 I acted as a consultant to and expert witness for the GESMO Utility group in that same proceeding. I was an expert witness for Duke Power Company concerning the Table S-3 radon issue in the Perkins proceeding from 1979 through 1982. On the subsequent appeal of that issue I acted as an expert witness for a consolidated utility group. In addition, I have appeared as an expert witness on environmental issues in more than two dozen administrative proceedings for nuclear and non-nuclear power plants, including cooling tower environmental impact issues for the Trojan, Davis Besse, Perry, and Palo Verde electric generating plants.

8. I have in the past served as U. S. representative to and chairman of an IAEA expert panel on Radioactive Waste Management at Nuclear Power Plants, resulting in IAEA Safety Series No. 28 of that title. Currently I am chairman of the Atomic Industrial Forum Ad Hoc Committee on the Clean Air Act and am a member of the Steering Group, AIF Committee on Environment and of the Standards Committee ANS-2 "Site Evaluation." I am also a member and the former chairman of the Nuclear Effects Committee, Environmental Engineering Division, ASCE.

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

9. In the fall of 1984, the Applicants retained NUS Corporation to conduct a modeling study of the drift deposition rates for the VEGP natural draft cooling towers. NUS Corporation set out the results of that study in a report entitled "An Evaluation of Cooling Tower Drift Deposition at the Vogtle Electric Generating Plant" dated January 29, 1985.

A. Description of the NUS Corporation's FOG Drift Deposition Model.

10. NUS Corporation predicted the drift mineral deposition patterns to be expected from the operation of the natural draft cooling towers at VEGP by using the NUS FOG computer code. That code calculates the release, plume rise, transport, and deposition of drift droplets from natural and mechanical draft cooling towers and other heat dissipation systems. The drift deposition routines in FOG consist of the following three calculational procedures: (1) the sequential release of the entrained drift droplets from the effluent plume, (2) the subsequent horizontal transport of the drift droplets as they fall to the ground, and (3) the calculation of the airborne concentrations and deposition rates of drift minerals at prespecified downwind distances for each of the sixteen wind directions.

11. In calculating the sequential release of the entrained drift droplets, the FOG model assumes that the excess water vapor, the excess temperature, the vertical velocity, and the concentration of drift droplets follow a Gaussian distribution normal to the plume axis. The plume is assumed to extend two standard deviations away from the plume axis. The release of the entrained droplets at any point within the plume depends on the relative magnitudes of the vertical fall velocity of the droplets and the vertical velocity of the air in the plume. At each downwind distance under consideration, the FOG model compares these two velocities for the various size categories of droplets in the plume, and a fraction of the droplets is released. This process is repeated until all droplets are released from the plume. When the plume reaches its maximum height, the vertical velocity throughout the plume is zero. Any droplets remaining in the plume at the level-off point are then released.

12. Droplets released from the plume fall, first through the plume air and then through the ambient air beneath the plume. As the drift droplets fall, they are carried downwind by the ambient wind until deposited on the ground. The rate of fall of the drift droplets is proportional to their terminal velocity, which in turn is dependent on the droplet size. The droplet size can

change by evaporative processes, which depend on the physical and transport properties of the liquid droplets and the surrounding air. For relative humidities below 50%, complete evaporation of the drift droplets to dry particles is possible. The FOG model employs a stepwise procedure to compute the trajectory of the droplets by considering the above effects.

13. Deposition rates of drift minerals as wet droplets and dry particles are calculated for each of the sequential meteorological records included in a one year or more meteorological data set, with wind speeds increased with height according to a power law relationship. These calculated deposition rates are then summarized to obtain the mineral deposition (in terms of pounds per acre per year) over the entire grid.

14. One of the sites at which the NUS Corporation's FOG model has been used to predict drift deposition rates is the Palo Verde Nuclear Generating Station ("Palo Verde"). During the course of the Palo Verde licensing proceeding NUS retained an independent consultant to evaluate the adequacy of the FOG computer code. The consultant selected was Dr. William Dunn, of Champaign, Illinois, who had co-authored a report of an earlier study of mathematical models for evaluating cooling tower drift deposition performed for the Nuclear Regulatory Commission

("NRC") and who was a principal contributor to the development of the most current computer models for prediction of cooling tower plume and drift behavior on behalf of the Electric Power Research Institute (EPRI). (A. J. Policastro, W. E. Dunn, M. L. Breig and J. P. Ziebarth, "Evaluation of Mathematical Models for Characterizing Plume Behavior from Cooling Towers. Volume 2. Salt Drift from Natural Draft Cooling Towers," NUREG/CR-1581, Vol. 2, U.S. NRC, 1980. W. E. Dunn, et al., "Studies on Mathematical Models for Characterizing Plume and Drift Behavior from Cooling Towers," Report CS-1683, Electric Power Research Institute, 1981.)

15. In July of 1983, Dr. Dunn issued a report concerning his evaluation of the FOG model entitled "Evaluation of NUS/FOG Computer Model for Predicting Cooling Tower Drift Deposition Rates." As stated in that report, Dr. Dunn, in his review of the FOG model, compared (a) the episodal predictions of FOG routines with the experimental field data collected during the Chalk Point Cooling Tower Project, as well as with the predictions of eleven other drift deposition models that had been evaluated in the earlier NRC-sponsored study; (b) the episodal predictions of FOG with field data from the Pittsburg (California) study, as well as with the predictions of the EPRI model for those conditions; and (c) the seasonal/annual predictions of the FOG model for Palo Verde with those of the

EPRI model. Chalk Point utilizes a natural draft cooling tower while Pittsburg and Palo Verde use mechanical draft cooling towers. With respect to comparisons (a) and (b) above, Dr. Dunn concluded:

> The results of the Chalk Point Study revealed that, for these limited data, the FOG model fell into a category of six out of twelve models which could be classified as "better performing." The results of the Pittsburg comparison were inconclusive due to limitations inherent in the measured data, although both the FOG and EPRI models gave reasonable predictions, in a subjective sense.

16. The evaluation of the FOG model and its comparison with the EPRI model for Palo Verde included determining the effects on predicted drift deposition patterns of using three different specifications of the drift droplet size spectrum that were provided to Dr. Dunn. The first of these was a spectrum provided to NUS by Research-Cottrell (referred to as FOG73), divided into five size classes, or bins. The second and third specifications each represented one droplet size spectrum (referred to as FOG81) but subdivided that spectrum in one instance into ten bins and in the other into 38 bins. The latter spectrum was the "default spectrum" adopted by NUS in 1981 based on an evaluation of the technical literature on cooling tower drift studies for use in the absence of tower-specific information.

17. With respect to the comparison of the predictions of the FOG and EPRI models for Palo Verde, Dr. Dunn wrote:

The comparison of the seasonal/annual predictions using the Palo Verde site data indicated that the FOG and EPRI models gave similar predictions for two drop spectra with appreciable fractions of large drops [the FOG81 droplet size spectrum]. For a third spectra devoid of larger drops [the FOG73 droplet size spectrum], the predictions were qualitatively different although of similar magnitude in the off-site areas. Overall, the comparisons were remarkably similar in light of the major difference between the methodologies of the two models.

B. Information Used in Running the NUS Corporation's FOG Model for the VEGP Natural Draft Cooling Towers

18. As with most contemporary computer models, the FOG code requires detailed information concerning the meteorological parameters of the site, the design and performance characteristics of the towers, the size distribution of the droplets emitted as drift, and the chemical composition of the droplets.

1. Meteorological Data.

19. The meteorological data used in modeling the drift deposition for VEGP consisted of hour-by-hour meteorological records taken from the site meteorological tower for two one year periods, from April 4, 1977 to April 4, 1978 and from April 1, 1980 to March 31, 1981. Meteorological data from the latter year was used by the Applicants in deriving their prior predictions of cooling tower drift based on a comparative analysis of drift data predictions from other plants, and the earlier year is

considered by the Applicant's meteorological consultant to be representative of average site meteorology. (Personal Communication from Mark Abrams, Pickard, Lowe and Garrick, Inc., December 1984.) Annual wind roses for these two data years are presented in Figure 12-1.

20. Since the tower plume rises considerably higher than the elevation of the site meteorological tower, the reasonableness of using the site meteorological data as a basis for the calculations was verified by comparing it to wind data measured by the Savannah River Laboratory at higher elevations on a 1000 foot television tower across the Savannah River from the VEGP. These data are presented as annual wind roses in Figure 12-2. (US DOE-Savannah River Laboratory supplied data tape; see also Hoel, D., "Climatology of the Savannah River Plant Site," DP-1679, June 1984.) Aside from expected increases of wind speed with elevation, and a slight change in wind direction with height, the data from the Savannah River Laboratory agree well with those taken from the VEGP meteorological tower.

2. Design and Performance Characteristics of the VEGP Natural Draft Cooling Towers.

21. The majority of the information about the VEGP natural draft cooling towers used in the analysis came from the VEGP operating license stage Environmental Report

("OL-ER"), § 3.4, supplemented with more detailed information on tower design details provided to the Applicants by Research-Cottrell, the tower manufacturer, as described in the affidavit of Daniel H. Warren at paragraph 17. A tabulation of the pertinent tower design and operating parameters used as input to the FOG model is shown in Table 12-1.

3. Size Distribution of Drift Droplets.

22. Information specific to the VEGP cooling towers was not available concerning the mass distribution by droplet size of the water droplets comprising the drift emitted from the tops of the towers during plant operation. Therefore, NUS examined values reported for other natural draft towers with the objective of selecting mass-size distribution spectra to bound the likely range of drift droplet sizes, and the consequent deposition patterns. The references reviewed were (1) Chen, N.C.J., and Hanna, S.R., "Drift Modeling and Monitoring Comparisons," Atmospheric Environment, Vol. 12, pp. 1725-1734, 1978; (2) DeVine, J.C., "The Forked River Program: A Case Study in Salt Water Cooling," GPU Service Corporation, Parsippany, NJ, February 1974; (3) Personal Communication from Mark Abrams, Pickard, Lowe and Garrick, Inc., December 1984; (4) Susquehanna SES Operating License Stage Environmental Report, Figure 5.1.4, May 1978; (5)

Beaver Valley Power Station Unit 2 Operating License Stage Environmental Report, Appendix 3B; and (6) Grand Gulf Nuclear Station Environmental Report, Table 5.1.11, Amendment 5, February 1981. Based upon that examination NUS determined a conservative droplet mass-size spectrum that should be an upper bound for the actual droplet spectrum at VEGP and a realistic droplet mass-size spectrum that should be more representative of the actual droplet spectrum that will occur at VEGP.

23. The spectra examined are presented in Figure 12-3 as a probability distribution of mass versus droplet diameter. Of these distributions, those curves labelled 1 through 5 and HC represent measured data. The remaining curves either represent design objectives or assumptions, or are not specifically identified as measured spectra in the references reviewed.

24. Most of the curves shown in Figure 12-3 are relatively closely grouped, with mass median (50th percentile) diameters ranging from about 80 to 150 microns. Larger drift droplets, those in excess of a few hundred microns in diameter, tend to produce the most significant deposition because of their greater fall velocities and mass. Therefore, the droplet size distribution labelled "6" in Figure 12-3, with a mass median diameter in excess of 200 microns, was selected as a "conservative" spectrum almost certain to produce an upper bound deposition pattern.

Although the mass median diameter of the distribution labelled "4" attributed to the Pennsylvania State University measurements at the Keystone station is even greater, this distribution was measured by aircraft sampling in the plume rather than at the tower exit and was rejected as too deviant from the remainder of the spectra.

25. NUS Corporation uses the distribution labelled "NUS," with a mass median diameter of 100 microns, as the "default" spectrum for evaluations in which data specific to the particular natural draft tower under review are not available. A hypothetical distribution, the default spectrum is representative of most of those reported and therefore likely to be similar to droplet sizes (and resulting distribution patterns) observed from operating towers. Because of the absence of a droplet mass-size distribution specifically determined for the VEGP towers, the NUS default spectrum was used to provide the "realistic" values for this evaluation. Both of these spectra were distributed into 16 size classes, or bins, for use as input to the FOG code as presented in Tables 12-2 and 12-3 for the conservative and realistic distributions, respectively.

C. <u>Results of the NUS Modeling Study for VEGP</u>.

26. NUS Corporation ran the FOG model twice for each year of meteorological data, once with the conservative

droplet mass-size spectrum and once with the realistic droplet mass-size spectrum. Figures 12-4 and 12-5 reflect the isopleths of total mineral deposition (both in droplets and as dry particles) in pounds per acre per year for the conservative and realistic droplet size spectra, respectively, for the meteorological data year considered representative of site conditions. Figures 12-6 and 12-7 present corresponding results for the later meteorological data year.

27. Several conclusions can be drawn from the results produced by the FOG model, as shown in Figures 12-4 through 12-7:

1. Of the two input parameters varied, the meteorological data year and the drift droplet spectrum, the latter is by far the more significant, producing about an order of magnitude change in mineral deposition. This is generally consistent with observations by others.
2. The conservative drift droplet size spectrum produces a maximum mineral deposition of about 1.7 pounds per acre per year (0.16 kg/ha-mo) to the east of the cooling towers at the boundary of the plant site during the representative year of record. The less

typical year changed the shape of the deposition patterns somewhat and reduced the maximum to about 1 pound per acre per year (0.09 kg/ha-mo).

3. The realistic drift droplet spectrum produces an estimate of the maximum mineral deposition of about 0.1 pounds per acre per year (0.009 kg/ha-mo) at the plant site boundary east of the cooling towers during the representative year of record. This is a factor of 17 less than that resulting from the use of the conservative droplet spectrum. The less typical year yielded an estimate for maximum deposition at the site boundary of less than 0.1 pounds per acre per year, again located to the east of the towers.

4. Even the most conservative of the four runs shows a maximum total mineral deposition rate off the plant site of less than two pounds per acre per year (0.18 kg/ha-mo), of which NaCl is less than one-fourth and which is well below any value expected to result in adverse effects. For example, the Nuclear Regulatory Commission states in the Environmental Standard Review Plans for the

Environmental Review of Construction Permit Applications for Nuclear Power Plants, NUREG-0555, § 5.3.3.2 that: "Deposition of salt drift (NaCl) at rates of 1 to 2 kg/ha-mo is generally not damaging to plants."

II. The Effects of Chlorine Added to the Circulating Water System upon the Total Dissolved Solids in the Cooling Tower Drift.

A. The Addition of Chlorine to the Circulating Water Will Not Result in the Emission of Chlorine Gas from the VEGP Cooling Towers.

28. As described in paragraphs 12 through 14 of the Affidavit of Daniel H. Warren, during plant operation chlorine gas dissolved in water will be added to the water ultimately reaching the natural draft cooling towers in a sufficient amount to produce a residual "free available chlorine" ("FAC") of 0.2 mg/liter in the circulating water, except during Corbicula spawning season when a FAC of 1.0 mg/liter will be maintained. VEGP OL-ER, § 3.6.1.1 (Amendment 6). Free available chlorine is not chlorine gas, but "the concentration of unreacted hypochlorous acid and hypochlorite ions existing in the chlorinated water." White, G.C., Handbook of Chlorination, Van Nostrand Reinhold Company, New York (1972), p. 190.

29. The chlorine injected into the water by either the river water chlorination system or the circulating water chlorination system will be in the form of chlorine gas dissolved in water. When chlorine gas (Cl_2) is injected into water the following reaction occurs:

$$Cl_2 + H_2O = HOCl + H^+ + Cl^-$$

This reaction occurs very rapidly and has been found to be substantially complete in less than one second at temperatures of 1° Centigrade. The complete hydrolysis of the chlorine gas occurs in a few tenths of a second at 65° Fahrenheit. White, G.C., Handbook of Chlorination, (1972), p.183.

30. The time it will take the chlorinated water to reach the cooling towers at VEGP will far exceed the amount of time necessary for complete hydrolysis of the chlorine gas. The pipe run from the river water chlorination system to the cooling towers averages about 2,600 feet, and the effective diameter of the pipe is about 46 inches. Based on an average makeup water flow of 20,000 gpm per unit (OL-ER, Figure 3.3-1), the residence time in the pipe is calculated to be approximately six minutes. The distance from the circulating water chlorination system to the natural draft cooling towers is approximately 2,888 feet. These distances are for Unit 1, and the corresponding distances for Unit 2 would be greater.

(See Figure 1.2.2-1 of the VEGP Final Safety Analysis Report ("FSAR").) The diameter of each circulating water conduit is 12 feet. Based on a circulating water flow of 484,600 gpm (OL-ER, Table 3.4-1), for the water to flow from the point of chlorine injection to the natural draft cooling tower would take approximately five minutes.

31. Thus, complete hydrolysis of the chlorine gas will occur long before the chlorinated water reaches the cooling towers. Moreover, no conditions exist in the circulating water system that would hinder or reverse the hydrolysis process.

32. The magnitude of the hydrolysis constant is so great that "no measurable concentration of Cl_2 remains in solution when the pH of the chlorinated water is more than 3.0 and the total chloride concentration is less than 1,000 mg/l." Fair, Geyer and Okun, Water and Wastewater Engineering, Volume 2, Water Purification and Wastewater Treatment and Disposal, John Wiley and Sons, Inc., New York (1968), p. 13-16. The pH of the circulating water in the cooling towers at Plant Vogtle will be between 7.0 and 8.0 with chloride concentrations of 20 to 30 mg/liter. (OL-ER, Table 3.6-2) While the information in Table 3.6-2 of the OL-ER does not include chlorides that would result from the addition of chlorine to the circulating water system, even considering those additional chlorides, the chloride concentration in the circulating water would

still be much less than 1,000 mg/liter. Also, changes in the cooling water temperature do not result in any appreciable change in the hydrolysis constant. White, G.C., Handbook of Chlorination, (1972), p. 183. Therefore, the increase in the temperature of the circulating water resulting from its passage through the condenser subsequent to the injection of the chlorine would have no appreciable effect on the hydrolysis of the chlorine gas in the water.

33. In summary, chlorine gas dissolved in water would be injected into the water that eventually reaches the cooling towers. Several minutes will be required for the water to travel from the point of injection to the cooling towers, while complete hydrolysis of the chlorine gas should occur within a few seconds of injection. The pH level of and the total chloride concentration in the circulating water would not interfere with this hydrolysis process. The water will contain no measurable chlorine gas when it reaches the natural draft cooling towers, and no measurable chlorine gas could be released from the cooling towers.

B. Additions to the Drift from the VEGP Cooling Towers Resulting from the Injection of Chlorine.

34. As described above, no chlorine gas will exist as such in the cooling tower water. Instead, the chlorine will exist either as HOCl (hypochlorous acid), as OCl^-

(hypochlorite ion), or as (reacted) hypochlorites or chlorides. The distribution between the hypochlorous acid and hypochlorite ion is a function of temperature and pH and can be calculated as follows:

$$(HOCl,/[(HOCl)+(OCl^-)] = 1/[1+(Ki/(H^+))]$$

where (HOCl), (OCl^-), and (H^+) are molar concentrations and Ki is the ionization constant, which varies with temperature. White, G.C., Handbook of Chlorination, (1972), p.185. At a pH of 7.5, the fractions of FAC represented by HOCl at temperatures of 89° and 122° Fahrenheit (the cold and hot water temperatures, respectively) are 0.43 and 0.37, respectively.

35. Chlorine demand is produced by those constituents of the raw and circulating water that combine with or form complexes with chlorine to create a form other than FAC. These other forms may be "combined residual chlorine" ("CRC") or some chlorine-containing compounds that cannot be defined as CRC. Chlorine that has been reduced to chloride by any reductant, or that has been combined with organic compounds by oxidation or substitution, is not considered to be any part of the total residual chlorine ("TRC"), which is the sum of FAC and CRC.

36. One element of the chlorine demand is that established by the chemical composition of the makeup water from the Savannah River, as given for example in Table 3.7-1 of the VEGP Construction Permit Stage Environmental

Report ("CP-ER"). Ammonia and nitrites in the makeup water will combine with the added chlorine, as will organic nitrogen compounds not identified in the analyses reported. Rather than calculate a theoretical demand value based on chemical composition, it is customary to determine that value empirically.

37. The breakpoint chlorine demand of the Savannah River water has been measured by the Applicants (GPC, Plant Vogtle Makeup Water Study, 1978) and has indicated, on average, the requirement for a chlorine dosage of about 5.5 mg/liter to produce a FAC residual of 1 mg/liter in the river water. That value might be used as one basis for estimating the quantities and the significance of potential discharges from the cooling tower of these chlorination products. Those demand determinations, however, do not indicate the demand to be exercised by the fouling organisms that will be developing within the operating plant. Thus, to provide a worst case emission and deposition evaluation, this analysis uses the maximum addition of chlorine specified in section 3.6.1.1 of the OL-ER.

38. As indicated in Table 9.3.7-1 of the FSAR, the River Water Chlorination System has two 6000 pound per day chlorinators and the Circulating Water Chlorination System, three 10,000 pound per day chlorinators. With an

average makeup water flow rate of 20,000 gallons per minute per unit, the two river water chlorinators can add about 25 mg/liter of chlorine to the makeup water. However, section 3.6.1.1 of OL-ER indicates that chlorination will be continuous up to a level of 10 mg/liter during the Corbicula spawning season to maintain a FAC residual of 1 mg/liter. This dosage would be continued for a period of about one week per month. The maximum concentration produced in the condenser cooling water flow of 484,600 gallons per minute by a 10,000 pound per day chlorinator is about 1.7 mg/liter.

39. Since analytical calculation of the precise fate of the added chlorine is not feasible, conservative estimates have been made of the distribution of the chlorine derivatives. It is assumed that all of the added chlorine except for the FAC and CRC is present as chloride ion, and adds to the dissolved chlorides (about 5 mg/liter) already introduced into the system by the makeup water from the river. It is further assumed that the CRC is composed of 0.6 mg/liter of monochloramine formed by the reaction of the hypochlorous acid with the 0.21 mg/liter ammonia contained in the makeup water. (CP-ER, Table 3.7-1.)

40. Of the 1.67 pounds of chlorine added per minute to the makeup water from the river, about 0.083 pounds per minute is assumed to combine with the ammonia to form monochloramine; 1.59 pounds per minute is assumed to

become chloride ion. Of the 6.94 pounds per minute added to the circulating water, all but the amount producing the FAC of 1 mg/liter adds to the chlorine-derived chlorides. The FAC and CRC are assumed to follow the behavior of the circulating water passing through the cooling tower; i.e., the fraction carried into the vapor phase will be the same as the fraction of water evaporated.

41. Assuming operation of the cooling towers at four cycles of concentration, the added "chlorides" would increase the drift (and blowdown) dissolved solids concentration at equilibrium from 240 mg/liter to about 440 mg/liter (an unrealistically high value) and increase the drift mineral deposit during that period by the same proportion (440/240). Thus, if the practice were to be continuous on a year-round basis, the previously estimated maximum drift deposition from both towers of 1.7 pounds per acre-year discussed in paragraph 27 above would increase by 1.4 pounds per acre per year to 3.1 pounds per acre per year. However, since such a high dosage practice would occur for one week per month for each unit from April to November (OL-ER, Response to NRC Question E291.15), for an equivalent of two months per unit per year, the maximum deposition value would increase to 1.7 + 1.4/6, or 1.93 pounds per acre per year.

42. The FAC and CRC in the circulating water are assumed to be lost to the atmosphere with that fraction of

the circulating water (15,000 gpm) that evaporates. At a concentration of 1 mg/liter of FAC and 0.6 mg/liter of CRC, the evaporate would transfer 15,000 gpm x 8.345 lb/gal x 1.5 lb (FAC+CRC)/1,000,000 lb water = 0.19 lb/minute of FAC and CRC. As vapors these materials would be dispersed as gases and would not deposit on the ground as promptly, or at as high a deposition density as the drift droplets. However, to be conservative, it can be assumed as an upper limit that the FAC and CRC deposited would follow the deposition patterns of minerals originating in the liquid drift droplets. Since the emission rate of those minerals leading to the maximum drift deposition estimate of 1.7 lb/acre-year is 0.155 lb/min, it can be estimated that the upper limit of FAC and CRC deposited would be at a rate of (.19/.155) x 1.7 = 2.1 pounds per acre per year for each unit. Again, since this maximum chlorination practice occurs for an equivalent of two months per year per unit, the maximum increment would be about 0.69 pounds per acre per year from both units, even accepting the highly conservative deposition assumption.

43. Adding these "chlorination" contributions at the maximum location (0.23 pounds per acre per year from added "chlorides" plus 0.69 pounds per acre per year from the FAC and CRC) to the (approximately) 8% of the drift mineral comprised of the chloride ion from the river makeup

water (0.14 pounds per acre per year) yields a total estimated "chloride" deposition of 1.06 pounds per acre per year. This value is well below any level of significance to vegetation.

Morton I. Goldman

Morton I. Goldman

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

Joyce Conway

Notary Public

My Commission Expires:

July 1, 1986

(NOTARIAL SEAL)

TABLE 12-1

VOGTLE ELECTRIC GENERATING PLANT
COOLING TOWER DESIGN AND OPERATING PARAMETERS

Parameter	Value per Tower	
Number of towers	2 (1 per unit)	(a)
Height, feet	550	(b)
Exit diameter, feet	303	(b)
Heat dissipated, BTU/hr	8×10^9	(a)
Range, °F	33	(a)
Circulating water flow, gpm	484,600	(a)
Expected drift rate, %	0.008	(c)
Avg. blowdown TDS conc, mg/l	240	(d)
Avg. concentration factor	4	(d)

(a) Vogtle Electric Generating Plant - OLSER, Table 3.4-1
(b) Vendor design information
(c) Letter, H.D. Burnum, Southern Co. Services, Inc. to M.Shuman, Research-Cottrell, Dec. 14, 1984.
(d) Vogtle Electric Generating Plant - OLSER, Table 3.6-2

TABLE 12-2

"CONSERVATIVE" DRIFT DROPLET DISTRIBUTION [a]

Bin No.	Diameter Range, microns	Representative Diameter, microns	Mass Fraction %	Cumulative Mass Fraction, %
1	<50	30	5	5
2	50 - 80	65	6	11
3	80 - 120	100	9	20
4	120 - 140	130	6	26
5	140 - 160	150	7	33
6	160 - 180	170	6	39
7	180 - 200	190	8	47
8	200 - 220	210	8	55
9	220 - 240	230	6	61
10	240 - 260	250	7	68
11	260 - 290	275	6	74
12	290 - 320	305	7	81
13	320 - 360	340	6	87
14	360 - 400	380	5	92
15	400 - 450	425	4	96
16	>450	500	4	100

Mass Median Diameter = 208μ

(a) See Figure 12-3, Curve "6"

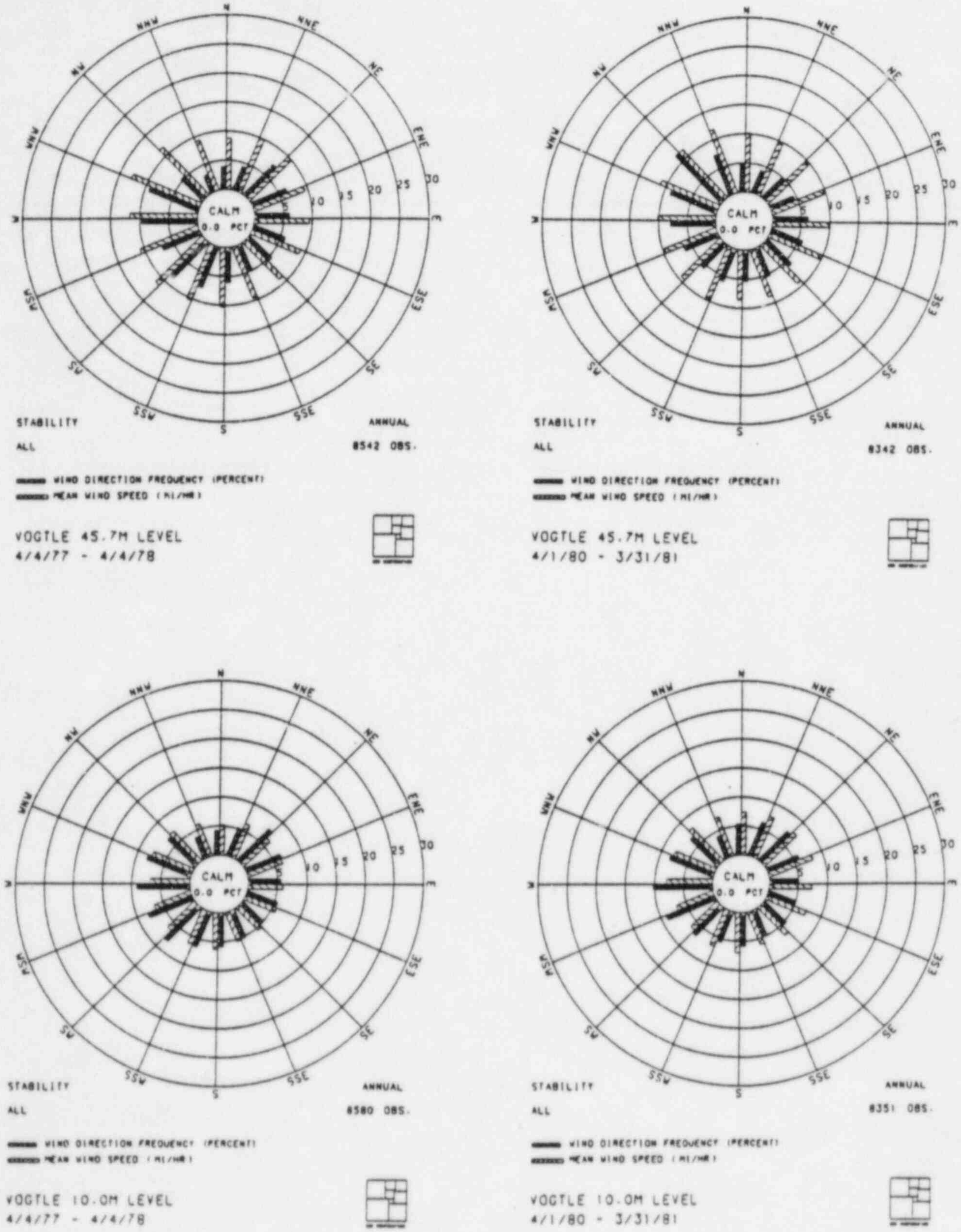
TABLE 12-3

"REALISTIC" DRIFT DROPLET DISTRIBUTION [(a)]

Bin No.	Diameter Range, microns	Representative Diameter, microns	Mass Fraction, %	Cumulative Mass Fraction, %
1	<30	20	2	2
2	30 - 40	35	4	6
3	40 - 50	45	6	12
4	50 - 60	55	7.5	19.5
5	60 - 70	65	8.5	28
6	70 - 80	75	8	36
7	80 - 90	85	8	44
8	90 - 100	95	7	51
9	100 - 110	105	7	58
10	110 - 120	115	6	64
11	120 - 135	127.5	7	71
12	135 - 150	142.5	6	77
13	150 - 180	165	8.5	85.5
14	180 - 220	200	6.5	92
15	220 - 300	260	5.4	97.4
16	>300	350	2.6	100

Mass Median Diameter = 98μ

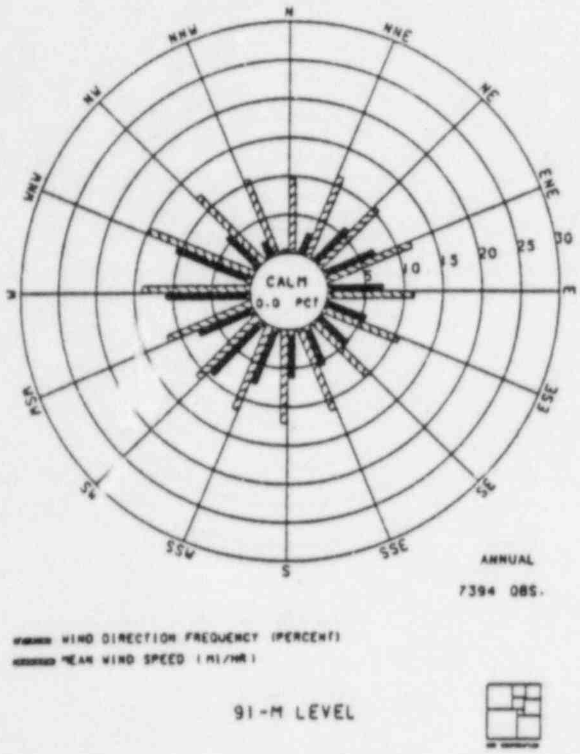
(a) See Figure 12-3, Curve "NUS"

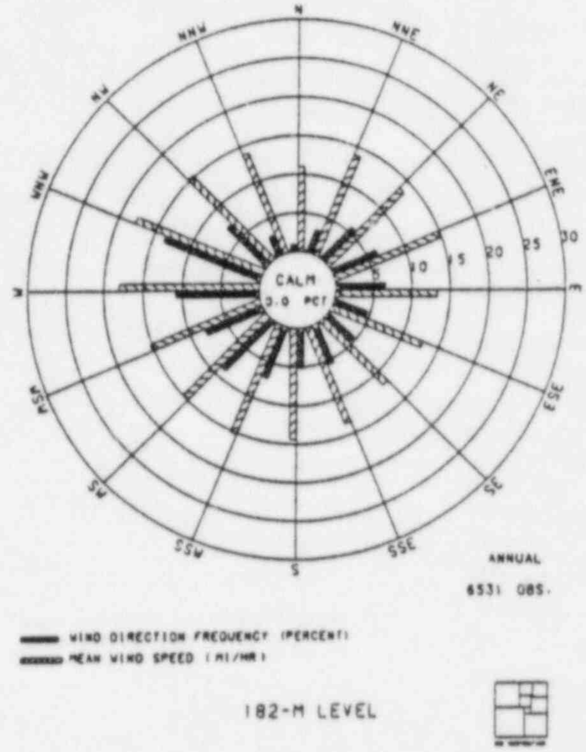


1977-78

1980-81

Figure 12-1
ANNUAL WIND ROSES
VOGTLE ELECTRIC GENERATING PLANT





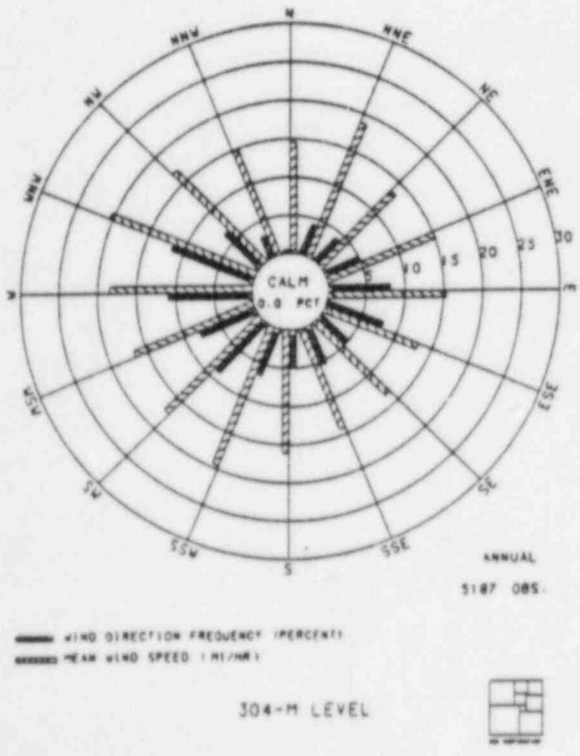
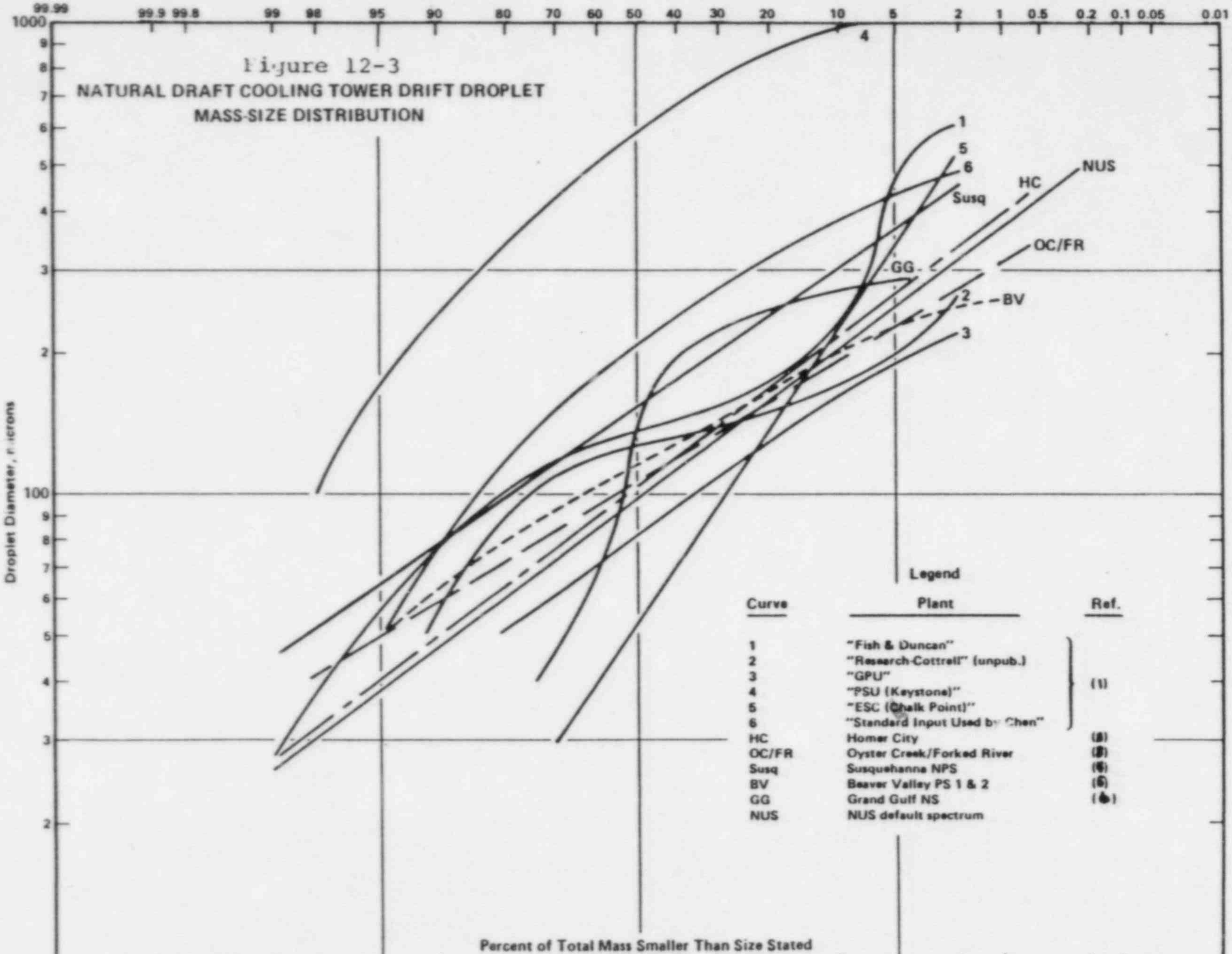
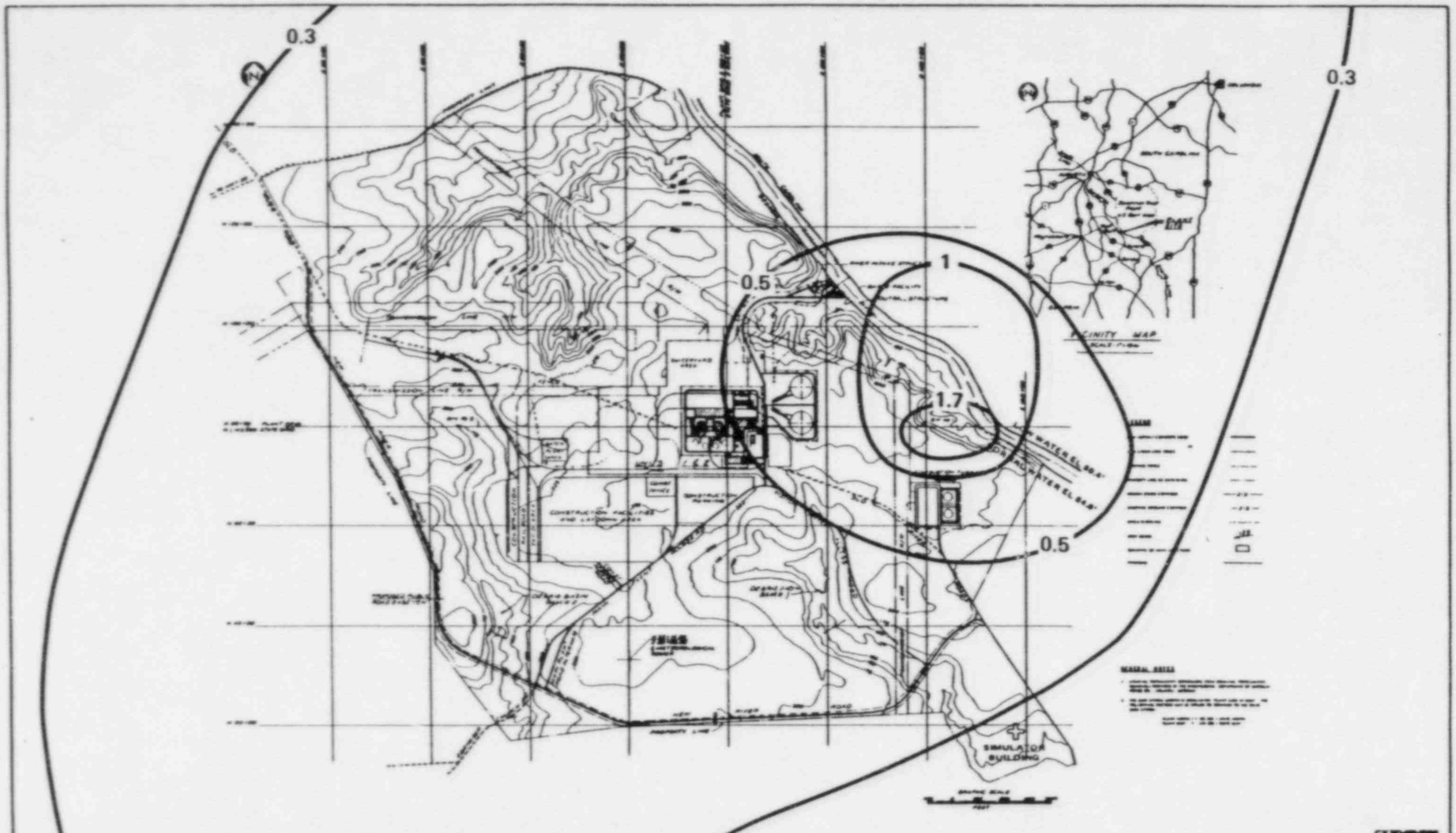


Figure 12-2
ANNUAL WIND ROSES
WJBF-TV TOWER
SAVANNAH RIVER LABORATORY DATA
4/4/77 - 4/4/78

Figure 12-3
NATURAL DRAFT COOLING TOWER DRIFT DROPLET MASS-SIZE DISTRIBUTION



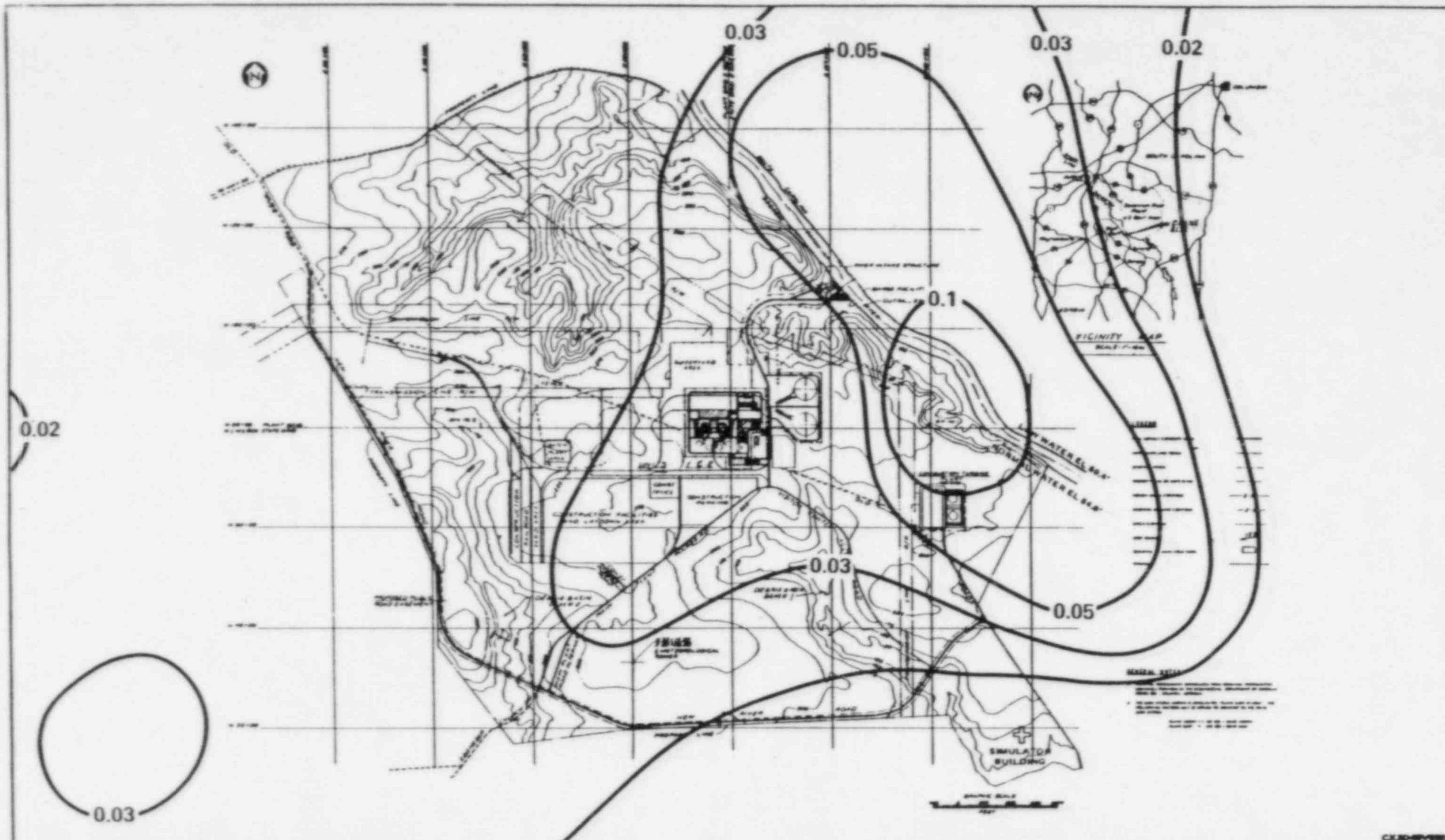


Georgia Power

VOGTLE ELECTRIC GENERATING PLANT UNIT 1 AND UNIT 2

COOLING TOWER DRIFT DEPOSITION

Figure 12-4



Total Salt from Two Units, lb/acre-year

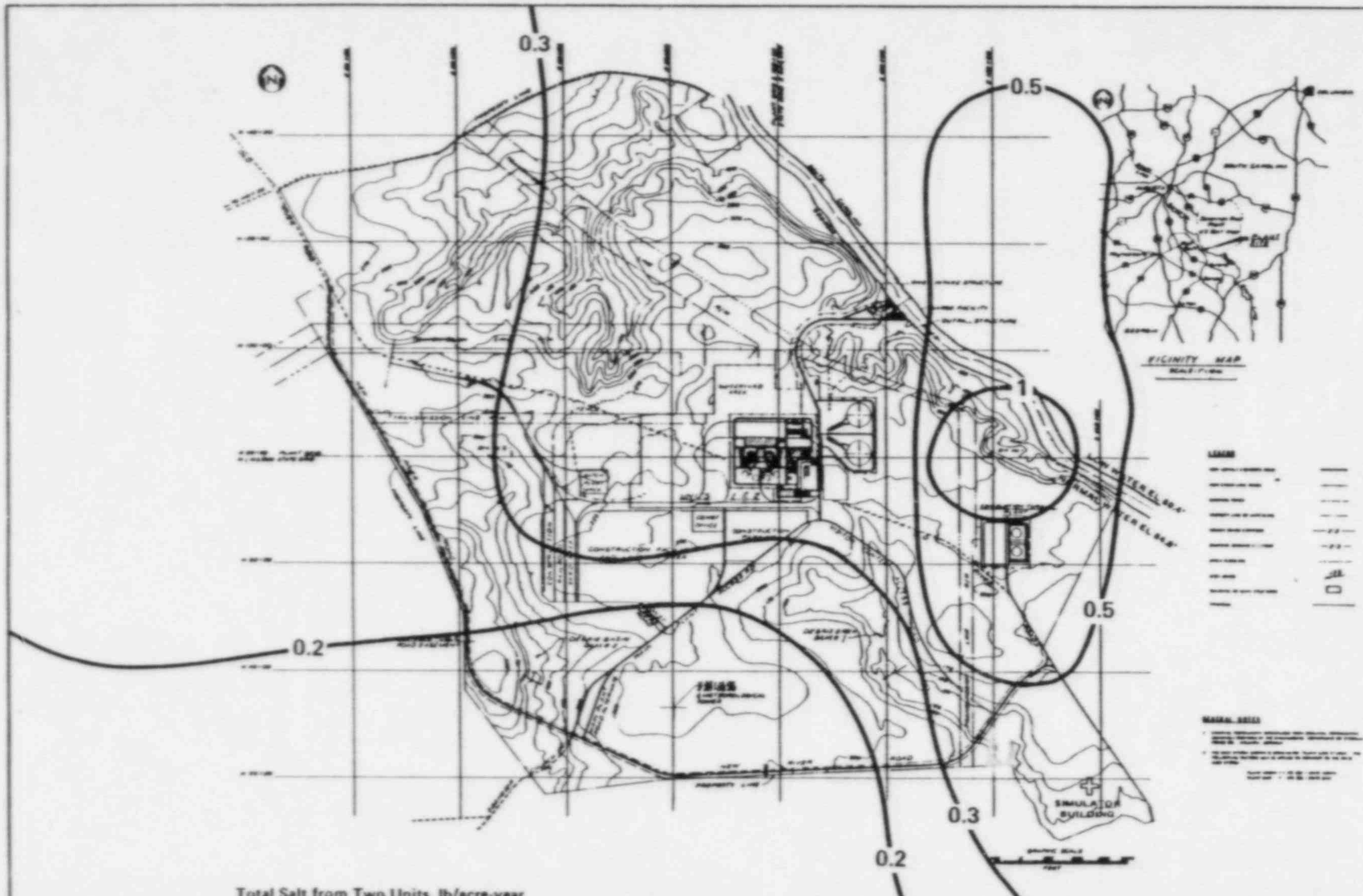
Particle size distribution:	Realistic
Met. data record year:	4/4/77 - 4/4/78
Drift rate:	0.008%

Georgia Power

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

COOLING TOWER DRIFT DEPOSITION

Figure 12-5



Total Salt from Two Units, lb/acre-year

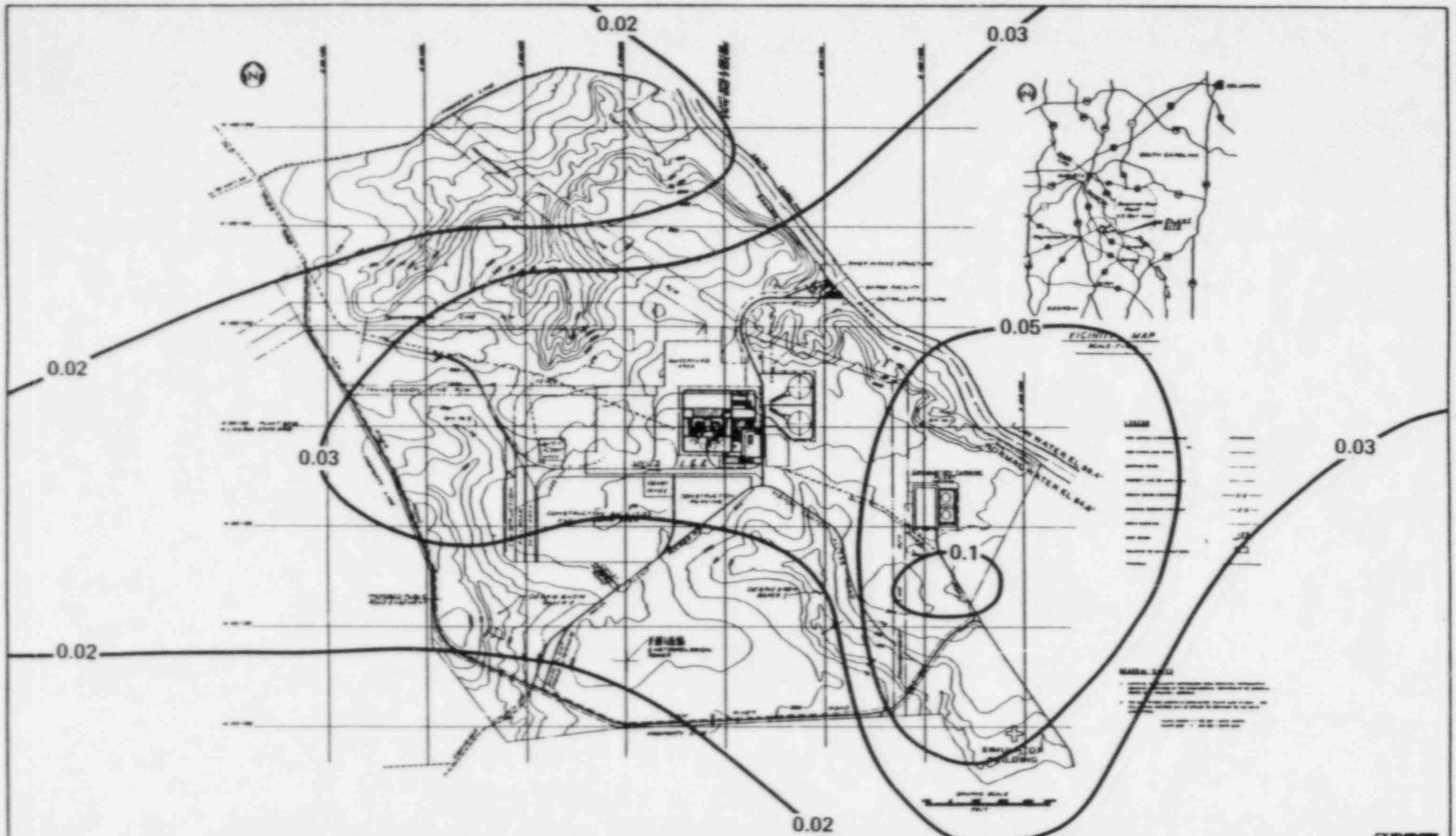
Particle size distribution: Conservative
Met. data record year: 4/1/80 - 3/31/81
Drift rate: 0.008%

Georgia Power

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

COOLING TOWER DRIFT DEPOSITION

Figure 12-6



Total Salt from Two Units lb/acre-year

Particle size distribution:	Realistic
Met. data record year:	4/1/80 - 3/31/81
Drift rate:	0.008%

Georgia Power

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

COOLING TOWER DRIFT DEPOSITION

Figure 12-7

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)	:	

CERTIFICATE OF SERVICE

I hereby certify that copies of the Affidavit of Morton I. Goldman, 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

James E. Joiner
Attorney for Applicants

Dated: July 11, 1985

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)	)	

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