February 7, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT COMPANY AND NORTH CAROLINA EASTERN MUNICIPAL POWER AGENCY	)	
	)	Docket Nos. 50-400 OL
(Shearon Harris Nuclear Power Plant, Units 1 & 2)	)	50-401 OL

APPLICANTS' STATEMENT OF MATERIAL FACTS AS TO WHICH THERE IS NO GENUINE ISSUE TO BE HEARD ON WELLS EDDLEMAN'S CONTENTION 83/84B

Pursuant to 10 C.F.R. § 2.749(a), Applicants state, in support of their motion for summary disposition of Wells Eddleman's Contention 83/84B in this proceeding, that there is no genuine issue to be heard with respect to the following material facts:

1. The Atomic Safety and Licensing Board has characterized Eddleman Contention 83/84B as questioning whether the health effects of halogenated organic compounds that are carcinogenic as a result of the chlorination of cooling waters in the Harris Plant have been assessed. Memorandum and Order (Ruling on Motions for Summary Disposition of Eddleman Contentions 29/30, 64(f), 75, 80 and 83/84), dated November 30, 1983.

2. On December 21, 1983, the Board of Directors of Carolina Power & Light Company (CP&L) approved the cancellation of Unit 2 of the Shearon Harris Nuclear Power Plant. Letter of E.E. Utley, Executive Vice President of CP&L, to Harold R. Denton, Director of the Office of Nuclear Reactor Regulation for the NRC, dated December 21, 1983; Affidavit of William T. Hogarth ("Hogarth Affidavit") at 2.

3. The cancellation of Unit 2 means that the Cape Fear water intake structure has also been cancelled because make-up water from the river will no longer be needed for Harris plant operations. Hogarth Affidavit at 2.

4. Thus the only possible mixing of SHNPP discharges with Cape Fear River water would occur where Buckhorn Creek flows into and mixes with the Cape Fear downstream of Buckhorn Dam. Hogarth Affidavit at 2.

5. It has been predicted by a study done by Lawler, Matusky & Skelly Engineers (LMS) that no free available chlorine would be discharged to the Harris reservoir or the Cape Fear River. Hogarth Affidavit at 3.

6. Models done by LMS conservatively estimated that total residual chlorine concentrations in the Harris lake and the Cape Fear River would be extremely small. Hogarth Affidavit at 3.

7. Studies performed on the discharges of other known nuclear power plants which use a hyperbolic cooling tower indicate that the only chlorination by-products formed and discharged which are regulated as known or suspect carcinogens are chloroform, other halomethanes, and 2, 4, 6-trichlorophenol. Affidavit of Dr. James A. Fava and Mr. Hans Plugge ("Fava Affidavit") at 6.

8. Chloroform and other halomethanes are within the grouping of halogenated organic compounds called haloforms. 2, 4, 6-Trichlorophenol falls within the subset of halogenated organics known as halophenols. Chlorination dosages and discharge concentrations of the haloforms and halophenols from the report of Dr. Roger M. Bean and dilution calculations from the models done by LMS conservatively show that the concentrations of these compounds which may be found in the Harris reservoir and in the Cape Fear River at the confluence of Buck Horn Creek are extremely minimal. The haloform concentrations in the 200-acre mixing zone allowed by the NPDES permit was 0.009 ppb, and where Buckhorn Creek flows into the Cape Fear River, concentrations were estimated at 0.00005 ppb. Halophenol concentrations in the same locations were estimated to be 0.005 ppb, and 0.00003 ppb, respectively. Fava Affidavit at 8.

9. Comparisons of these estimated concentrations to bioaccumulation data and Environmental Protection Agency water quality criteria for consumption of aquatic organisms demonstrates concentrations of haloforms and halophenols even in a 5 acre mixing zone in Harris reservoir would be at least 100 times lower than the EPA water quality criteria for the applicable designated use of Harris reservoir waters. The concentrations of those chemicals at the Cape Fear River would be 0.003 percent of EPA criteria for surface water used for drinking purposes and 0.0004 percent of the criteria for fish consumption only. Id. at 12.

10. Risk assessment analysis indicates the probability of incurring cancer as a result of the incremental contribution by SHNPP to haloforms in drinking water from the Cape Fear River would be 1 in 3,850,000,000 given 70 years of exposure. The risk for halophenols is 1 in 40,000,000,000. Both risks are substantially below even the most conservative risk estimates used by the EPA. Id. at 13.

11. Further comparison of the estimated concentrations of the SHNPP discharges was made to trihalomethanes concentrations found in drinking waters of North Carolina. The haloform concentration from SHNPP discharges calculated at the confluence of Buckhorn Creek with the Cape Fear River averages 200,000 to often 1 million times lower than concentrations normally encountered in North Carolina municipal drinking water supplies. Id. at 17.

12. There will be no measurable increase in health risks to those using Harris reservoir for recreational purposes (including fish consumption) or those drinking, or eating organisms from, Cape Fear River water downstream of SHNPP as contended. Id. at 18.

13. Health effects which might be caused by the formation of halogenated organic compounds that are carcinogenic as a result of the chlorination of the cooling waters in the Harris plant have been adequately assessed and have been demonstrated to have no adverse impact on the cost/benefit balance under NEPA.

This the 7th day of February, 1984.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT COMPANY	)	
AND NORTH CAROLINA EASTERN	)	Docket Nos. 50-400 OL
MUNICIPAL POWER AGENCY	)	50-401 OL
	)	
(Shearon Harris Nuclear Power Plant,	)	
Unit 1)	)	

AFFIDAVIT OF JAMES A. FAVA AND HANS PLUGGE
IN SUPPORT OF SUMMARY DISPOSITION OF
EDDLEMAN CONTENTION 83/84B (CHEMICAL DISCHARGES)

County of Baltimore)
)
State of Maryland)

James A. Fava and Hans Plugge, being duly sworn according to law, deposes and says as follows

1. We are Vice President and Senior Scientist, respectively, within the Scientific Operations Division of Ecological Analysts, Inc., Sparks, Maryland. We have personal knowledge of the matters set forth herein and believe them to be true and correct to the best of our knowledge, information, and belief. A statement of our professional qualifications and experience is attached.

2. Eddleman Contention Issues

On 30 November 1983, the Atomic Safety and Licensing Board stated that the affidavit of Dr. William T. Hogarth failed to address "the

effects on human health that might be caused by the formation of halogenated organic compounds that are carcinogenic, as a result of chlorination of the cooling waters in the Harris plant." This affidavit utilizes technical information to address these issues for the Shearon Harris Nuclear Power Plant (SHNPP).

In this affidavit, we will first show which carcinogenic organic chemicals may be present in discharges at SHNPP. Then we will analyze the most up-to-date report of chlorination and organic by-product formation to determine which carcinogens are formed within nuclear power plants. Next, based on chemical testing at other nuclear power plants, and mathematical modeling specifically for SHNPP, concentrations of carcinogenic organic by-products are conservatively estimated for both the reservoir and the Cape Fear River. Then, to assess the potential human health effects of these (suspected) carcinogens, exposure via both drinking water and the consumption of contaminated aquatic organisms is evaluated by comparing reservoir and river concentrations to appropriate U.S. EPA water quality criteria for the protection of human health.

3. In order to assess which carcinogens may be present in the discharge from SHNPP we first listed all chemicals expected to be present in the SHNPP discharges and then evaluated their carcinogenicity. The presence of chemicals in the discharge was based on the most comprehensive and up-to-date report of the formation of chemicals in cooling waters as a result of chlorination (Bean 1983). This report surveyed chlorination by-product formation at eight nuclear power

plants. Given the variety of power plant designs and their influence on chlorination by-product formation, it was felt that data for installations using natural draft cooling were the most representative with regard to predicting the chemicals expected to be formed as a result of SHNPP operation. SHNPP will use natural draft hyperbolic cooling towers. The Bean (1983) report evaluated three plants with similar systems:

- Arkansas Nuclear One, Unit #2, Russelville, Arkansas
- Beaver Valley Power Station, Unit #1, Shippingport, Pennsylvania
- Trojan Nuclear Plant, Rainier, Oregon

Furthermore, like SHNPP, each of these facilities discharges to freshwater.

Exhibit A details the chemicals found by Bean (1983) in discharge and intake waters of these three nuclear power plants. As evidenced by the fact that the analytical detection limits reported by Bean (1983) are one to three orders of magnitude lower than standard U.S. EPA priority pollutant analysis methodology (EPA 1982), the results presented by Bean (1983) are the best and most sensitive data presently available.

The determination of which of these chemicals found in the discharge are carcinogens or suspected carcinogens was based on careful reviews of U.S. EPA water quality criteria documents and the cancer research databases listed below:

- RTECS--Registry of Toxic Effects of Chemical Substances. Produced by the National Institute of Occupational Safety and Health (NIOSH) with the on-line data file maintained by the National Library of Medicine. Updated quarterly, RTECS contains data for approximately 53,000 substances.

- PHS-149--U.S. Department of Health, Education and Welfare's Survey of Compounds Which Have Been Tested for Carcinogenic Activity.

- CANCERLINE--Sponsored by the International Cancer Research Data Bank Program of the National Cancer Institute, this database contains over 260,000 citations pertaining to all aspects of cancer. It is updated monthly with approximately 4,000 citations.

- NCI BIOASSAY--National Cancer Institute reviews and summary of NCI carcinogenicity tests.

- IARC Review--Monographs by the International Agency for Research on Cancer which address the carcinogenic risks of numerous chemicals to humans.

Exhibit A includes the following suspect carcinogens which were determined to be present in cooling water discharges evaluated in the Bean (1983) report:

Volatiles
- carbon tetrachloride
- chloroform
- 1,1-dichloroethylene
- 1,2-dichloropropane
- methylene chloride
- (tri)halomethanes
  (bromodichloromethane, chlorodibromomethane, tribromomethane)
- tetrachloroethylene
- trichloroethylene

Phenols
- 2,4,6-trichlorophenol

Base-Neutral
- dichlorobenzene

It should be noted here that, although 2-chlorophenol has been reported to cause skin papillomas following topical applications, U.S. EPA currently deems the scientific evidence inadequate to regulate 2-chlorophenol as a carcinogen (see also Section #7 of this affidavit and Exhibit D).

Although these carcinogens were determined to be present in discharges, the majority of them were not produced as a result of chlorination but were instead already present in intake waters (see Section #4 below).

4. Following the identification of carcinogens which may be present in the discharge from SHNPP, one needs to determine which of these chemicals are actually formed as a result of chlorination of the cooling water. Exhibit B presents an extensive discussion of the results of Bean's report (1983) as well as personal communications with Dr. Roger M. Bean (1984). Based on this discussion and the results presented in Section #3 of this affidavit, only the following chemicals will be considered in our discussion of health effects of carcinogens present in Cape Fear River and SHNPP reservoir waters:

Chloroform

Halomethanes (the sum of bromodichloromethane, chlorodibromomethane, and tribromomethane)

2,4,6-Trichlorophenol

Please note that chloroform and 2,4,6-trichlorophenol are the only two identified carcinogens formed in the plant as a result of chlorination and discharged. The trihalomethanes are regulated by U.S. EPA as suspect carcinogens based on their structural similarity to chloroform but without sufficient data to indicate their actual carcinogenic potency, if any. Also note that all of these carcinogens are present in intake water, albeit at lower concentrations (Exhibit A).

5. Concentrations of chlorine and chlorination by-products expected to result from operation of SHNPP were addressed by Lawler, Matusky and Skelly Engineers (LMS). This LMS study is included as an exhibit in

Dr. W.T. Hogarth's affidavit. Based on the LMS study, we calculated the following equations which mathematically describe the dilution processes occurring between end-of-pipe discharge, two different mixing zones in the reservoir (5- and 200-acre) and the contribution/ dilution to the Cape Fear River. These equations are as follows:

Equation 5.1

Chemical Concentration (ppb) in 5 acre mixing zone
= chemical flux (lb/day) at end-of-pipe x 0.42

Equation 5.2

Chemical Concentration (ppb) in 200 acre fully mixed mixing zone
= chemical concentration (ppb) in 5 acre fully mixed mixing zone x 0.025

Equation 5.3

Chemical concentration (ppb) discharged to Cape Fear
= chemical concentration (ppb) in 200 acre fully mixed mixing zone x 0.57

Equation 5.4

Average incremental contribution from SHNPP for chemical to Cape Fear (ppb)
= chemical concentration (ppb) discharged to Cape Fear x 0.01

As an estimate of the quantity of discharged by-products that were created by the chlorination of nuclear power facilities, power plant specific chemical data presented in Bean (1983) were utilized to calculate the formation rates of haloforms and halophenols which might be expected from SHNPP chlorination practices. Exhibit C presents estimated daily discharges of haloforms and halogenated phenols by the three operating nuclear power plants studied by Bean

(1983) which use natural draft hyperbolic cooling towers and discharge into freshwater. Exhibit C indicates that a maximum level of 0.12 percent of the initial chlorine dose is recovered at end-of-pipe as haloforms in the cooling water discharge plume. Similarly, a maximum of 0.07 percent of the initial chlorine dose is recovered at end-of-pipe as halophenols in the discharge. Thus, using a maximum total chlorine dose of 725 pounds/day at SHNPP, Ecological Analysts (EA) computed a maximum haloform discharge of 0.87 pounds/day. Using the equations above, this discharge is diluted to 0.36 ppb over a 5-acre mixing zone (Equation 5.1) and to 0.009 ppb over the NPDES permitted 200-acre mixing zone (Equation 5.2). The average incremental total haloform input to the Cape Fear River is estimated to be only 0.00005 ppb (Equations 5.3 and 5.4). Using EA's estimate of 0.07 percent of the chlorine dose forming halogenated phenols, the total halogenated phenol levels would be approximately half of the total haloform inputs computed above. Thus, over the NPDES permitted 200-acre mixing zone, the concentration of halogenated phenols is estimated to be 0.005 ppb and the incremental halogenated phenol dose to the Cape Fear River would be 0.00003 ppb, a very small contribution (Exhibit E).

Although not accounted for in this assessment, the already low halogenated organic concentrations that are predicted in both the reservoir and the river would be reduced further as a result of evaporative transport, especially at the reservoir spillway into Buckhorn Creek, during the 2.5-mile transit down Buckhorn Creek and

the 15 miles of the Cape Fear River prior to the water's first consumptive use at Lillington. It is noteworthy that the Final Environmental Statement and the LMS exhibit (see Hogarth affidavit) indicate that no free chlorine will be released into the reservoir thereby precluding the formation of chlorinated compounds in the reservoir itself or in the Cape Fear River.

6. As aquatic species have been demonstrated to bioaccumulate many chemicals, there is a potential that consumption of contaminated organisms could adversely affect human health. The protection of human health from contaminated aquatic organisms is carefully considered by the U.S. EPA's water quality criteria. Thus the criteria for chloroform, halomethanes, trichloroethylene, tetrachloroethylene, 2,4,6-trichlorophenol, and dichlorobenzene include specific terminology which limit the concentrations of these chemicals in water from which aquatic organisms are consumed (see the column titled "At 10^{-5} Consumption Only" in Exhibit D).

For the halogenated carcinogens found in the power plant as a result of chlorination (see Section #4 above), U.S. EPA's water quality criteria documents report the following bioaccumulation data which indicate that bioaccumulation potentials for these chemicals are low:

Chloroform - The bioconcentration factor (BCF) was determined to be 6 in 14 days (EPA 1980a p. B-2). This means that in 14 days, concentrations of chloroform measured in tissues were only six times higher than the concentration in the exposure water.

Halomethanes - "no residue data for freshwater fish are available for halomethanes other than for chloroform and carbon tetrachloride, for which bioconcentration factors were 6 and 30 respectively." (EPA 1980b p. B-3)

2,4,6-Trichlorophenol - "no measured steady-state BCF is available for trichlorophenols, but the equation 'Log BCF = (0.85 Log P)-0.70' can be used to estimate the steady state BCF for aquatic organisms." (EPA 1980c p. C-53).

It is noteworthy that Bean (1983) performed a limited study of bioaccumulation and concluded that "no halogenated material was found to be bioaccumulated in mussels [the only organisms evaluated] exposed to the chlorinated discharge of a marine power station (Millstone)."

Under contract to the U.S. Nuclear Regulatory Commission, Anderson and Lusty (1980) researched the bioaccumulation and depuration of chloroform by four freshwater fish species: rainbow trout (Salmo gairdneri), bluegill (Lepomis macrochirus), largemouth bass (Micropterus salmoides), and channel catfish

(Ictalurus punctatus). The authors concluded that "in all species tested, the bioaccumulation of chloroform from the concentration in the water [1.0 to 1.5 ppm] was less than one order of magnitude" (Anderson and Lusty 1980, p. 11.) Depuration rates were also experimentally shown to be rapid.

7. The potential for human health effects from the consumption of contaminated aquatic species and/or drinking water for these three carcinogens can be assessed by direct comparison with appropriate water quality criteria (see Exhibit D). Unlike water quality standards, criteria are not enforceable numbers. Rather, they utilize the most complete database available to indicate concentrations that will protect human populations from adverse health effects which might result from continuous lifetime exposures. Thus, when states establish enforceable water quality standards, the published U.S. EPA criteria are used as guidance, and the resulting standards are almost always higher (less stringent) than the criteria on which they are ultimately based. Chloroform represents a classic example of this, as the water quality criterion for drinking water is 1.9 ppb whereas the enforceable primary drinking water standard is 100.0 ppb (Exhibit D). Using the bioaccumulation potential data discussed in Section #6 above, U.S. EPA calculated the following water quality criteria which are specifically designed to protect human health from the consumption of aquatic organisms living in a waterbody:

Compound	10^{-5} Criterion
Chloroform	157.0 ppb
Halomethanes	157.0 ppb
2,4,6-Trichlorophenol	36.0 ppb

The reservoir concentrations (within a 5-acre mixing zone) which are expected to result from the operation of SHNPP are conservatively estimated to be at least 100 times lower than these appropriate criteria which are established specifically to protect humans from the consumption of contaminated aquatic organisms (Exhibit E). A far greater degree of safety will exist relative to concentrations expected in the 200-acre mixing zone and in the Cape Fear River (Exhibit E). Thus, concentrations of haloorganics in the reservoir will, even using extremely conservative assumptions, be less than 1 percent of U.S. EPA water quality criteria for the protection of human health corresponding to the North Carolina Class C use category of the reservoir, i.e., recreational with no drinking water consumption.

The incremental contribution of total haloforms from SHNPP discharges into the Cape Fear River is expected to be at most 0.00005 ppb, less than 0.003 percent (three one-thousandth of one percent) of the EPA water quality criteria for surface water used for drinking purposes, and 0.00004 percent of the U.S. EPA water quality criteria for fish consumption only (Exhibit E). Both of these numbers were calculated assuming a health effect probability of 10^{-5}. These health effect probabilities (see also Exhibit D) indicate the exposure levels

(i.e., 4.9 ppb for chloroform in water) which need to be consumed for 70 years to result in an upper limit likelihood (highest chance) of contracting one additional case of cancer in a population of 100,000. Note that the number does not imply that 1 in 100,000 will get cancer, but that the highest possible chance (at 95 percent confidence upper limit) will be 1 in 100,000. These models highly overestimate risk, and the "average" risk is normally 1 to 4 orders of magnitude lower than the "upper limit" risk used in the criteria (Rodricks and Taylor 1983). The incremental contribution of SHNPP discharges to total halophenols in the Cape Fear River is expected to be at most 0.00004 ppb or 0.0005 percent of the U.S. EPA water quality criteria for drinking water for 2,4,6-trichlorophenols (Exhibit E).

The actual "risk levels" associated with the haloforms and halophenols are as follows:

	Halophenols	Haloforms
200-acre dilution zone		
Fish consumption	1.4×10^{-9}	5.7×10^{-10}
Cape Fear River		
Drinking water	2.5×10^{-11}	2.6×10^{-10}
Fish consumption	8.3×10^{-12}	3.1×10^{-12}

What this means is that the probability of incurring cancer as a result of SHNPP contribution to haloforms in drinking water from the Cape Fear River would be 2.6×10^{-10} or 1 in 3,850,000,000 given 70 years of exposure to the 0.00005 ppb in Cape Fear River water. These

levels are far below even the most strict (conservative) estimates of 1 in 10,000,000 (10^{-7}) provided by U.S. EPA in their water quality criteria.

Such calculations, as made above, inherently incorporate some very conservative assumptions:

- all haloforms are carcinogenic (not proven)
- all haloforms are as potent as chloroform (not proven)
- the methodology used to calculate the cancer risk estimate is very conservative and uses upper 95 percent confidence limits rather than mean values resulting in overestimation of risk by several orders of magnitude (Ruckelshaus 1983)
- assumes that all of the haloforms and halophenols present in the discharges are formed in the plants, whereas much of the concentration discharged was already present in the intake waters of the facility (see Exhibits A and B)
- all halophenols are carcinogenic (not proven)
- all halophenols are as toxic as 2,4,6-trichlorophenol (not proven)
- no evaporative transport, metabolism, or binding to organic material occurs between the discharge point and the Cape Fear River
- there is no dilution beyond the 200-acre mixing zone in a 4,000-acre reservoir

- SHNPP chlorination will result in a formation rate for haloforms and halophenols equal to the highest rates observed in Bean (1983), rather than the average rate.

Thus, at the 10^{-5} criteria level, all applicable U.S. EPA water quality criteria for the organohalochemicals formed as a result of chlorination practices at SHNPP are expected to be met with at least two orders of magnitude safety margin in the reservoir (5-acre mixing zone) and at least four orders of magnitude in the Cape Fear River beyond the levels established by U.S. EPA for the protection of human health. It is also important to note that the concentrations of regulated haloorganics within the SHNPP reservoir (5-acre and 200-acre mixing zones) and the Cape Fear River also comply with U.S. EPA water quality criteria for the protection of human health at the much more conservative 10^{-6} and 10^{-7} criteria. Stated differently, this means that expected concentrations also comply with the federal criteria which are conservatively designed to limit the highest possible chance of producing 1 additional cancer in a population of 1,000,000 (at 10^{-6}) and a population of 10,000,000 (at 10^{-7}). As noted by Dourson and Stara (1983), these U.S. EPA criteria already have several safety factors incorporated during their development.

8. In order to put the concentrations of trihalomethanes (THMs) and other chlorination by-products further into perspective, it is informative to compare expected SHNPP effluent concentrations with concentrations measured in finished drinking waters of North Carolina. Based on mathematical modelling by LMS for SHNPP, and measured

discharge concentrations at nuclear power generation facilities studied by Bean (1983) which utilize natural draft cooling towers, total haloform levels in the reservoir (200-acre mixing zone) are expected to be approximately 0.009 ppb. The nearest downstream community that withdraws water from the Cape Fear River for consumptive purposes is Lillington (Harnett County). Therefore, prior to human consumption, these already low THM concentrations will be reduced via simple dilution and volatilization during transit down 2.5 miles of Buckhorn Creek and an additional 15 miles down the Cape Fear River before reaching the Lillington water treatment plant.

Like most municipal water treatment plants, Lillington utilizes chlorination to disinfect water supplies to protect public health. As in power plant applications, THMs are an unavoidable by-product of municipal drinking water chlorination. Based on conversations with Lassiter (1984 personal communication) measured total THM concentrations for the four municipalities of the Harnett County Utilities system for the last three quarters of 1983 are presented below.

Community	Summer (August 1983) (ppb)	Spring (May 1983) (ppb)	Winter (February 1983) (ppb)
Lillington	134	116	61
Buies Creek	210	158	89
Coats	186	155	120
Angier	195	135	87

The geometric mean of these total THM finished drinking water measurements is 129.5 ppb, a value which is more than 14,000 times higher than the haloform concentration in the reservoir estimated to occur as a result of SHNPP chlorination activities and more than 2,500,000 times higher than SHNPP's expected contribution of haloforms into the Cape Fear River.

Although these Harnett County total THM finished drinking water measurements occasionally exceed the U.S. EPA's primary drinking water standard of 100 ppb (Exhibit D), total THM concentrations in the Lillington water supply system are not atypical of North Carolina municipal water supplies. Singer et al. (1982) evaluated THM formation in nine of the larger cities in North Carolina. Average THM concentrations in finished waters ranged from 11 ppb in Asheville to 120 ppb in Raleigh (Exhibit F). Finished water THM concentrations in Durham were reported to average 55 ppb, a concentration that is 6,000 times higher than are conservatively estimated to be present in the SHNPP reservoir and 1,000,000 times higher than SHNPPs estimated haloform contribution to the Cape Fear River. These data show that concentrations normally encountered in North Carolina municipal drinking waters are at least 200,000 times and often one million times higher than those expected to be discharged into the Cape Fear River by the operation of SHNPP.

9. In conclusion, it is our opinion based on the evidence presented above that operation of SHNPP and the organohalogen levels that are expected to be produced will not result in a measurable increase in health risk to either the population using the reservoir for recreational purposes (including fish consumption) or the use of Cape Fear water for drinking water or recreational purposes.

4 February 1984

James A. Fava

Hans Plugge

Sworn to and subscribed before me, this the 4th day of February 1984.

Carol L Carmine
Notary Public

My Commission Expires July 1, 1986

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EXHIBIT A. COMPOUNDS IDENTIFIED IN SAMPLES FROM NUCLEAR POWER PLANTS
(All Concentrations in Parts-Per-Billion)

	Arkansas Nuclear One Unit #2		Beaver Valley Power Station, Unit #1		Trojan Nuclear Plant	
	Intake	Discharge	Intake	Discharge	Intake	Discharge
Volatiles						
1,1-Dichloroethylene			tr	0.1		
1,1-Dichloroethane			0.01			
1,2-Dichloropropane	0.2	0.2				
1,3-Dichloropropane, (cis + trans)						
Methylene Chloride			0.1	0.4	5.9	2.9
Bromodichloromethane		0.7	0.02	0.06		tr
Chloroform	0.2	0.7	0.3	0.5	0.2	0.3
1,1,2,2-Tetrachloroethane						
1,2-Dichloroethylene			0.1			
1,2-Dichloroethane			0.02			
Chlorobenzene						
1,1,1-Trichloroethane			0.1			
Carbon Tetrachloride				tr		
Chlorodibromomethane		0.8	0.3	0.1		
Trichloroethylene			0.2	0.2	0.03	0.03
Tetrachloroethylene	3.1	2.5	0,1		0.01	0.02
Bromoform		0.2	tr	tr		

Note: MS = Identified by GC/MS analysis of XAD-2 extracts, but not found by electron capture analysis of 1-liter extracts.
tr = Concentrations detected by electron capture detectors but were below 0.1 ppb.

Source: Bean (1983).

EXHIBIT A (CONT.)

	Arkansas Nuclear One Unit #2		Beaver Valley Power Station, Unit #1		Trojan Nuclear Plant	
	Intake	Discharge	Intake	Discharge	Intake	Discharge
Phenols						
Chloro		MS	MS	MS	MS	
Chloromethyl		MS				
Bromo		MS		MS		
2,6-Dichloro		MS	0.01	0.02		0.01
2,5- or 3,5-Dichloro		MS	MS	MS	tr	0.01
Bromochloro		MS		0.01		tr
2-Bromo-4-Chloro		tr		0.01		
4-Bromo-2-Chloro		tr		tr		
2,4,6-Trichloro		0.01	tr	0.03	0.02	0.1
Chloronitro				MS		
2,6-Dibromo		0.01		0.02		
2,4-Dibromo		MS	tr	0.03		
Bromodichloro #1		0.05	0.01	0.06	MS	0.1
Bromodichloro #2		0.03		0.05		0.06
Dichlorodimethyl				tr		0.02
Bromodimethyl						
Dichloronitro						
Bromonitro #1		0.11				
Bromonitro #2		0.03				
2,4-Dibromo-6-Methyl		0.01				
Dibromochloro #1		0.1	tr	0.06	tr	0.03
Dibromochloro #2		0.2	tr	0.07	tr	0.04
Bromodichloromethyl #1		0.01				
Bromodichloromethyl #2		0.01				
2,4,6-Tribromo	tr	0.4		0.1	MS	0.01
Tribromomethyl		0.1				
Base-Neutrals						
Dichlorobenzene	tr	tr	tr	tr	tr	tr
Trichlorobenzene			tr	tr	tr	tr
Dibromoiodomethane		tr				

EXHIBIT B FORMATION OF (SUSPECT) CARCINOGENS IN COOLING WATERS OF NUCLEAR POWER PLANTS FOLLOWING CHLORINATION FOR BIOFOULING CONTROL

This exhibit discusses in detail the formation of three classes of chlorinated chemicals--volatiles, phenols, and base-neutrals as a result of chlorination of cooling waters in nuclear power plants. These three classes are defined as follows:

volatiles-a group of chemicals which volatilize (go into the gaseous state) easily at room temperature, and are analyzed by purging (bubbling air through a vessel) the volatiles out of a water sample into a trap.

phenols-a group of chemicals having the basic structure of a benzene group with a hydroxyl substitution. They are analyzed following extraction from an acidified water sample, and are thus often called acid-phenols.

base-neutrals-a group of chemicals which is nonvolatile and nonphenolic. They are analyzed following extraction from either a basic or neutral water sample and are thus known as base-neutrals.

Exhibit A identifies the specific chemicals found in operating nuclear power plant intakes and discharges for each of these three chemical groupings. Conclusions regarding which chemicals are formed

in nuclear power plant cooling waters are based on the data presented in Bean (1983) for the three operational nuclear facilities mentioned in Section #3 of this affidavit, as well as personal communications with Dr. Roger M. Bean (January 1984).

Volatiles

For the volatiles at the Arkansas Nuclear One, Unit #2, the data presented in Bean (1983) indicate that chloroform is the only identified carcinogen of the volatiles group formed in the plant, although the other trihalomethanes (bromodichloromethane, chlorodibromomethane, and bromoform = tribromomethane) are regulated by U.S. EPA (45 Federal Register 79318) as suspect carcinogens under the assumption they have the same potency as chloroform based on structure-activity relationships. 1,2-Dichloropropane and tetrachloroethylene are not formed in the cooling water but are instead present in the intake water (Exhibit A). Because these volatiles were not created by the operation of the plant, they are not of concern regarding this contention.

At the Beaver Valley Power Station, Unit #1, the only identified carcinogen formed is chloroform, while a single trihalomethane (bromodichloromethane) is also formed. 1,2-Dichloroethylene, methylene chloride, 1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, chlorodibromomethane, trichloroethylene, and tetrachloroethylene are not formed in the plant. The conclusion regarding the non-formation of methylene chloride is based on its

constant concentration in the intake and tower basin (Bean 1983), observations at other plants, as well as the possibility of laboratory variability. Using the analytical methods of Bean (1983), the minimum detection (precision) limit for volatiles that is quantifiable with certainty is 0.1 ppb (Roger Bean, personal communication 1984). This means that numbers quantified as $\leq$0.1 ppb cannot be used to indicate the formation of a chemical within a power plant with certainty. Although bromoform appears to be formed as evidenced by its elevated concentration in the tower basin (Bean 1983), there is no net discharge. 1,1-Dichloroethylene is not considered to be formed by plant operations based on the low concentration detected and the presence of 1,2-dichloroethylene in the intake and not in the discharge.

At the Trojan Nuclear Plant, Bean's (1983) data indicate that only chloroform and a single trihalomethane (bromodichloromethane) are formed in the plant. Methylene chloride and tri- and tetrachloroethylene are not formed in the plant. Tetrachloroethylene was deemed to be not formed based on (1) its absence from the tower basin, (2) the results from the two other plants, and (3) confirmation by Bean (1984 personal communication).

Phenols

2,4,6-Trichlorophenol is a confirmed carcinogen and is appropriately regulated by the U.S. EPA (45 Federal Register 79318, and Exhibit D). The data collected by Bean (1983) indicate that 2,4,6-trichlorophenol

was the sole carcinogenic phenol formed at each of the three plants studied.

Base Neutrals

None of the base-neutrals appear to be formed during chlorination of cooling water at any of the three plants studied by Bean (1983). Further discussion of this chemical group thus appears unwarranted.

Thus, chloroform and 2,4,6-trichlorophenol are the only identified carcinogens formed in the cooling waters of these three operating nuclear power plants. The data also indicate that trihalomethanes are also formed within the plants. Trihalomethanes are regulated by U.S. EPA (45 Federal Register 79318) as (suspect) carcinogens based on their structural similarity to chloroform, and assuming they have the same dose-response and potency data as chloroform.

It is noteworthy that both of the carcinogens that are expected to be formed within the plant are also present, albeit at somewhat lower levels, in intake waters.

EXHIBIT C. ESTIMATED DAILY DISCHARGE OF HALOFORMS AND HALOGENATED PHENOLS BY NUCLEAR POWER PLANTS

Facility	Chlorine Dose pounds/day[a]	Haloforms Discharged grams/day[b]	Percent of Dose that is Haloforms	Halophenols Discharged grams/day[b]	Percent of Dose that is Halophenols
Arkansas Unit #2	125	70	0.12	17	0.03
Beaver Valley Unit #1	250	67	0.06	22	0.02
Trojan	250	120	0.11	75	0.07

(a) Source - Table 2 of Bean (1983).
(b) Source - Table 22 of Bean (1983).

EXHIBIT D. U.S. EPA CRITERIA FOR THE PROTECTION OF HUMAN HEALTH

	Maximum Concentration (ppb)	Organoleptic (ppb)	Health (ppb)	At 10^{-5} Drinking and Consumption (ppb)	At 10^{-5} Consumption Only (ppb)
Applicable U.S. EPA Priority Pollutants, 28 NOV 80 (45 Fed Reg 19318)					
Volatiles					
Carbon tetrachloride				4.0	69.4
Chloroform				1.9	157.0
Haloethers			No data		
Halomethanes				1.9	157.0
Pentachlorophenol		30.0	1,010.0		
Trichloroethylene				27.0	807.0
Tetrachloroethylene				8.0	88.5
Chlorinated Phenols					
2-chlorophenol		0.1			
3-chlorophenol		0.1			
4-chlorophenol		0.1			
2,3-dichlorophenol		0.04			
2,4-dichlorophenol		0.3	3,900.0		
2,5-dichlorophenol		0.5			
2,6-dichlorophenol		0.2			
3.4-dichlorophenol		0.3			
2,3,4,6-tetrachlorophenol		1.0			
2,4,5-trichlorophenol		1.0	2,600.0		
2,4,6-trichlorophenol		2.0		12.0	36.0
2-methyl-4 chlorophenol		1,800.0			
3-methyl-6 chlorophenol		20.0			
Base Neutrals					
Dichlorobenzene				400.0	2,600.0
Applicable U.S. EPA Primary Drinking Water Standards					
Total Trihalomethanes	100				

EXHIBIT E. COMPARISON OF PREDICTED CONCENTRATIONS WITH U.S. EPA WATER QUALITY CRITERIA (All values in parts per billion (ug/liter)

	Halophenols	Haloforms
10^{-5} Consumption Criteria[a]	36.0[b]	157.0[c]
5-acre concentration	0.21	0.36
200-acre concentration	0.005	0.009
10^{-5} Drinking and Consumption Criteria[a]	12.0[b]	1.9[c]
200-acre concentration	0.005	0.009
Cape Fear River contribution	0.00003	0.00005

(a) U.S. EPA Water Quality Criteria published 28 November 1980 (45 Federal Register 79318).
(b) Most restrictive (lowest) of the health related criteria for any chlorinated phenol (2,4,6-trichlorophenol).
(c) Same criteria for chloroform and halomethanes.

EXHIBIT F. AVERAGE TOC AND THM CONCENTRATIONS FOR EACH OF THE FACILITIES INCLUDED IN THE NORTH CAROLINA SURVEY(a)

Treatment Facility	Raw Water TOC (ppm)	Finished Water INST THM (ppm)
Asheville	0.7	11
Chapel Hill	6.6	105
Charlotte-Hoskins	2.1	41
Charlotte-Vest	2.1	73
Durham	6.9	55
Gastonia	3.0	33
Greensboro-Mitchell	4.3	52
Greensboro-Townsend	4.2	32
Raleigh-Bain	4.5	120
Raleigh-Hohnson	6.4	90
Wilmington	7.7	148
Winston-Salem-Neilson	4.0	50
Winston-Salem-Thomas	4.8	47

(a) Each entry in this table, with the exception of Asheville, represents an average of at least three, and usually four, separate samples, collected at different times of the year, to avoid seasonal bias. In the case of Wilmington, a large portion of the samples were collected during the spring and summer months in order to evaluate the impact of Wilmington's decision to discontinue prechlorination on June 2, 1980.

Source: Table 14 in Singer et al. 1982.

ECOLOGICAL ANALYSTS, INC.

JAMES A. FAVA, Ph.D.
Vice President, Toxicology Services

Dr. Fava is responsible within Ecological Analysts for the management, design, and implementation of environmental toxicology and environmental health programs, including conceptual evaluations and bioassay assessments relating to the Clean Water Act, Ocean Dumping Act, RCRA, FIFRA, TSCA, and "Superfund." He actively participates as a working professional scientist/consultant and interacts directly with clients concerning technical evaluations, impact assessments, bioassay evaluations, computerized database development, legal and legislative implications, and program design and implementation.

EXPERIENCE:

BIOMONITORING (EFFLUENT TOXICITY TESTING): As a result of a number of research efforts, experience has been gained into the advantages, disadvantages, and limitations of conducting biological monitoring associated with NPDES permits. Activities have included the evaluation of the scientific validity of federal and regional guidelines for effluent toxicity testing (ETT); a survey of national, EPA region, and state approaches to ETT; participation in a joint EPA/industry (API, CMA, and UWAG) meeting on the appropriateness of ETT; and conduct of onsite/offsite toxicity testing.

WATER QUALITY REVIEWS: Directed and actively participated in critiques of proposed and existing state/federal water quality criteria, standards, and end-of-pipe limitations for a variety of industrial clients. Substances evaluated included ammonia, arsenic, asbestos, chlorine, cyanide, cadmium, copper, chromium, chloroform, chlorophenols, copper, iron, mercury, nickel, PAHs, and zinc. In addition, U.S. EPA's various guideline methodologies for deriving toxic substance water quality criteria have been comprehensively evaluated as they have evolved. Recent efforts have critiqued proposed water quality standard regulations including use-attainability analyses and the approach to site-specific criteria formulation.

WATER CHLORINATION: Extensive research on the toxicological and ecological impacts associated with the use of chlorination has been conducted. The use of chlorine to control biofouling on once-through cooling systems, including OTEC was assessed. Toxicological effects examined include acute and preference/avoidance testing on freshwater and marine fishes and macroinvertebrates. Some of these efforts have resulted in preparation and presentation of expert testimony. Conceptually, work has been conducted in areas of critiquing national and state draft chlorine water quality criteria

and developing specific technical sessions at the last two Water Chlorination Conferences.

OCEANOGRAPHIC EVALUATION: Activities included the collection of water quality and plankton samples, bottom cores, and various oceanographic research efforts while aboard NOAA's U.S. Research Ship Oceanographer during its year-long global cruise. Additional assessments relate to the biological, chemical, and toxicological evaluations of materials released--directly or dumped--into the marine environment. These efforts involved the integration of diverse scientific data and information into multidisciplinary assessments associated with predicting or measuring the impacts of man's activities in the oceans.

LEGISLATIVE ASSISTANCE: During reauthorization in 1982 and 1983 of the Marine Protection, Research and Sanctuaries Act of 1977, actively provided technical assistance to New York City's Washington D.C. office to support its efforts relevant to the Ocean Dumping Act Amendment of 1982. Activities included (1) discussions with various Congressional staff, (2) preparation of technical testimony to support Mayor Koch's testimony before Congressional hearings, and (3) a presentation before the entire staff of the Merchant Marine and Fisheries Committee of the House of Representatives concerning the adequacy of the existing Ocean Dumping Act and Regulations to allow for a comprehensive assessment of ocean dumping, including site designation rulemaking and special permit application.

SOLID/HAZARDOUS WASTE DISPOSAL: Evaluated the environmental effects of ocean dumped materials (e.g., sewage sludge in the New York Bight) and participated in a comparative multimedia assessment of the impacts of sewage sludge disposal by composting, incineration, and ocean disposal.

PHYSIOLOGY/TOXICOLOGY: Extensive research conducted on the physiological effects of chemical, thermal, and complex mixtures on numerous marine, estuarine, and freshwater fish species. Effects examined include preference/avoidance, lethal, sublethal, bioaccumulation, and acute responses. Additional research evaluated the acute toxicity of chlorine and ammonia and the interactive effects of chemical pollutants and temperature on the behavior of several estuarine organisms.

ENVIRONMENTAL IMPACT ASSESSMENT: Evaluated the potential impacts of point-source discharges relating to sewage treatment plant and industry operation. These efforts included water quality analysis, field biological assessments, effluent evaluations, literature

reviews, bioassays, biostatistics, and preparation of expert testimony.

STATE-OF-THE-ART REPORTS: Directed and participated in the preparation of monographs on cyanide, ammonia, and chromium that evaluated the sources, chemistry, environmental fate, and aquatic effects of these compounds. These efforts required the interaction of scientists from several disciplines.

CRITICAL REVIEW: Referee for technical papers submitted to the Transactions of the American Fisheries Society, Journal of The Fisheries Research Board of Canada, and Water Chlorination Conferences. Reviewed and critically examined the technical validity and appropriateness of various proposed federal and state environmental regulations as to protection of the aquatic environment. Recent activities included the critical evaluation of proposed onsite effluent toxicity testing protocols relevant to the second round of NPDES permits. These efforts included conceptual discussions with leading scientists, regulatory authorities, and attorneys relevant to the technical direction of the critiques.

CONFERENCE PLANNING: Organized and participated in the development of technical programs associated with scientific conferences, including the National American Fisheries Society's meeting, and the Third and Fourth Water Chlorination Conferences. As part of these activities, informal and formal discussion sessions were organized to provide increased exchange of information among scientists from various disciplines.

FACILITIES DEVELOPMENT: Designed, constructed, and directed the research programs of freshwater and estuarine laboratories. Facilities have featured static and flow-through capabilities designed for studies of acute toxicity, temperature preference, avoidance, thermal toxicity, and other chronic effects.

EDUCATION:

Ph.D. (behavioral toxicology), University of Maryland, College Park, Maryland 1975

M.S. (fisheries biology), University of Maryland, College Park, Maryland 1973

B.S. (zoology), University of Maryland, College Park, Maryland 1970

PREVIOUS EXPERIENCE:

ECOLOGICAL ANALYSTS, INC., Baltimore, Md.	
Manager, Environmental Toxicology Services	1980-1981
ECOLOGICAL ANALYSTS, INC., Baltimore, Md.	
Scientist, Environmental Toxicology and Chemistry Group	1977-1980
ICHTHYOLOGICAL ASSOCIATES, INC., Middletown, Del.	
Senior Research Biologist	1975-1977
UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL AND ESTUARINE STUDIES, College Park, Md.	
Faculty Research Assistant and Research Graduate Assistant	1970-1975
TRIDENT ENGINEERING ASSOCIATES, INC.	
Research Associate	1973-1974
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	
Assistant Survey Technician	1967-1968

PROFESSIONAL ACTIVITIES:

Society of Environmental Toxicology and Chemistry
American Association for the Advancement of Science
The American Fisheries Society
American Society for Testing and Materials
Atlantic Estuarine Research Society
Water Pollution Control Federation
Phi Sigma Society

COMMITTEES:

Society of Environmental Toxicology and Chemistry -
Publication Committee

PUBLICATIONS AND PRESENTATIONS:

Gift, J.J., J.A. Fava, A.F. Maciorowski, and W.L. McCulloch. 1983. The use and implication of sewage sludge toxicity tests in ocean disposal management divisions. Ocean Waste Management: Policy and Strategies. 2-6 May 1983. University of Rhode Island.

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Fava, J.A., A.F. Maciorowski, W.L. McCulloch, J.J. Gift, H.J. Reisinger, J. Edinger, and E. Buchak. A multidisciplinary approach to sewage sludge ocean disposal assessment. Accepted for presentation at the Fourth Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, Va.

SELECTED REPORTS AND CONSULTING EXPERIENCE:

American Petroleum Institute--

- Analyzed the literature on the source, chemistry, fate, toxicity (aquatic and human health), and detection of ammonia in surface waters.
- Prepared a critique of the literature on the source, chemistry, fate, toxicity, and detection of chromium in surface waters.
- Conducted a survey and analysis of the existing and proposed biomonitoring test procedures relevant to the petroleum industry.
- Evaluated the appropriateness of proposed effluent toxicity testing procedures relevant to their use with the petroleum industry.
- Evaluated an approach to conduct use attainability analyses for surface waters relevant to proposed water quality standard regulations.
- Assisted in the development of technical comments on protocols to derive site-specific water quality criteria.
- Provided technical support on the use of biomonitoring including effluent toxicity tests and ecological surveys for use in wasteload allocation and total daily maximum loads.
- Participated in a survey of national and state groundwater quality standards and aquifer classification systems.
- Directed technical literature reviews on the source, chemistry, toxicity (aquatic, human health) of cadmium and vanadium.

- Evaluated Michigan's proposed Rule 57 to control the release of toxic substances in Michigan surface waters. Interacted with State technical staff relevant to the technical suggestions.

Department of Energy--Evaluated the potential use of chlorine to control biofouling at OTEC plants.

Electric Power Research Institute--Evaluated the feasibility of integrating diverse environmental data into a numerical computerized database system to allow use of existing information for future applications, such as siting.

The Fertilizer Institute--Analyzed the literature on the aquatic toxicity, fate, and sources of ammonia in surface waters.

General Public Utilities Corporation--Prepared comments and testimony on the potential biological impact of chlorinated discharges from a power generating station on the Susquehanna River.

The Inter-Industry Cyanide Group--Conducted an overview and analysis of the literature on the chemistry, fate, toxicity, and detection of cyanide in surface waters.

Keystone Bituminous Coal Association--Conducted critique and prepared comments and testimony on State of Pennsylvania proposed revisions of water quality criteria for ammonia, cyanide, iron, phenol, and total dissolved solids as influenced by several stream flow scenarios.

Michigan Coalition for Clean Water--Evaluated the use of aquatic toxicological principals relevant to their use in Michigan's draft Rule 57.

Minnesota Industry Group--Conducted technical critique and prepared comments on Minnesota Pollution Control Agency's Proposed Water Quality Standards for ammonia and total residual chlorine.

New York City Department of Environmental Protection--

- Assessed existing scientific and technical information and data to address the appropriateness for designating three sites (12-mile, 65-mile, and 106-mile) for ocean disposal of sewage sludge.

- Evaluated draft amendments to the Ocean Dumping Act with respect to scientific framework to provide adequate protection to man and the environment.

- Evaluated the existing chemical, physical, toxicological, and field data as part of a permitting process to consider sludge disposal at various sites.

Pennsylvania Power and Light Company--Conducted technical review and prepared comments on State of Pennsylvania proposed revisions of water quality standards.

Public Service of New Jersey--Investigated the behavioral responses of estuarine and marine organisms to determine toxicity of chlorine and temperature.

Utility Water Act Group (UWAG)--

- Conducted technical critique and prepared comments on U.S. EPA Proposed Water Quality Criteria for the priority pollutants cadmium, copper, nickel, zinc, arsenic, chlorophenols, polynuclear aromatic hydrocarbons, chloroform, asbestos, chromium, and mercury.

- Conducted technical critique and prepared comments on U.S. EPA Draft Guidelines for deriving Water Quality Criteria for the protection of aquatic life.

- Conducted technical critique and prepared comments on U.S. EPA's proposed action to list ammonia as a toxic pollutant.

- Conducted technical critique and prepared Bioassay Evaluation Criteria for the review of the appropriateness of chlorine toxicity literature for use in deriving water quality criteria.

- Evaluated the precision and variability associated with the proposed preliminary effluent toxicity screening test.

- Prepared critique of U.S. EPA's proposed effluent toxicity testing protocols relevant to their validity and appropriateness for use in the second round of NPDES permits.

- Participated in a joint EPA/industry meeting (June 1981) on the appropriateness of using biomonitoring during the second round of NPDES renewals.

- Evaluated Draft Ambient Water Quality Criteria document on chlorine, including assessment of completeness, adequacy, and appropriateness of toxicological data for use in setting water quality criteria.

- Critiqued an approach to derive site-specific water quality criteria relevant to the proposed water quality standard regulations.

- Performed a sensitivity analysis on the use of procedures to calculate the water quality criterion's Final Acute Value (FAV). This was part of an evaluation of the usefulness of the "National Guidelines for deriving water quality criteria for the protection of aquatic life" to derive site-specific criteria.

- Reviewed internal draft versions of EPA's 1983 criteria documents for arsenic, cadmium, chronium, copper, cyanide, lead, and mercury.

- Directed an effort to address variability issues associated with EPA's national acute toxicity databases for 23 chemicals with the goal of developing a method to calculate the final acute values.

Water Resources Research Center--Studied the behavioral responses of freshwater fish to domestic sewage effluents and their toxic constituents--free chlorine, chloramines, and ammonia.

ECOLOGICAL ANALYSTS, INC.

HANS PLUGGE
Senior Scientist/Health Sciences and Risk Assessment

Mr. Plugge is the Senior Scientist for the Health Sciences and Risk Assessment group within the Environmental Toxicology division. As such, he is responsible for coordinating corporate services in risk assessment, risk perception, environmental and occupational health services, pollution monitoring systems and industrial hygiene and safety engineering. In addition, he provides expertise in toxicodynamics of xenobiotics in mammalian and other biota as well as structure-activity relations. Mr. Plugge is also the corporate Safety Manager.

EXPERIENCE:

OCCUPATIONAL AND ENVIRONMENTAL HEALTH: Managed the development of a dozen short health effect assessment documents as part of a multimedia sewage sludge risk assessment. Managed and developed the EPA Drinking Water Criteria Document on carbon tetrachloride. Managed and developed a review of nasal oncogens for CPSC that involved evaluation of 1,100 clinical and animal reports. Developed the mass balance for arsenic in the zinc industry. Reviewed numerous occupational health and safety studies in developing several health effects support documents on ITC chemicals list under TSCA for U.S. EPA. Managed the development of eight environmental and health effect chemical profiles for U.S. EPA. Developed two special hazard reviews for NIOSH. Developed carbon tetrachloride SNARL for EPA. Was safety officer in several academic chemistry and toxicology laboratories. Designed and manages EA's occupational safety and health program. Serves on the Corporate Committee on Occupational Safety and Health. Reviewed benzene, toluene, and xylene SNARLS as part of a gasoline derived ground-water contamination assessments.

RISK ASSESSMENT: Pioneered development of multimedia, multichemical risk assessment methodologies for evaluation of relative cost-effectiveness of engineering alternatives in controlling environmental releases and health risks. Developed methodology for uniform expression of health effect probabilities using perceived risk as a normalizing factor. Performed a 12 (15) chemical 3-media risk assessment of long-term sewage sludge disposal alternatives for the City of New York: incineration vs. ocean disposal. Developed methodology for evaluating cost-effectiveness of SUPERFUND Hazardous Waste Site Remedial Engineering Alternatives. Performed Picillo SUPERFUND site cost-effectiveness assessment of ground-water withdrawal and treatment alternatives. Managed a large-scale survey on the differential perception of diseases by several socioeconomic groups in the Baltimore SMSA. Performed hazard assessments of PAH soil contamination at two separate construction redevelopment sites. Present work in progress includes the development of a cost-benefit

risk assessment methodology for biofouling control alternatives in the utility industry and a cost-effectiveness assessment of remedial engineering alternatives at the Keefe Environmental Services SUPERFUND site.

REGULATORY REVIEW: Performed regulatory review of federal legislation, criteria documents and other publications. Participated in the review of several State regulations regarding water quality and waste management.

AIR SCIENCES: Managed the design, construction, and installation of a mobile and automated air quality system for volatile organs. Designed an automated air quality monitoring system for a hazardous waste site. Managed the development of air quality data using UNAMAP for sewage sludge incinerators.

MAMMALIAN TOXICOLOGY: Conducted studies on the hepatic effects of chlorinated ethylenes and chloroprene. Performed studies on the inhalation toxicity of chloroprene using pulmonary lavage. Conducted acute toxicity studies on NIAX-ESN, a polyurethane catalyst, resulting in,the identification of the causative agent of a clinical syndrome in exposed workers. Conducted a long-term feeding study of chloroacetaldehyde in rabbits. Conducted toxicity study on the interaction of PCBs with 1,1-dichloroethylene. Critically evaluated thousands of toxicology studies, both animal and human, on a variety of compounds, including aliphatic and aromatic hydrocarbons (chlorinated benzenes, biphenyls, terphenyls and naphthalenes, halogenated methanes, ethanes and ethylenes) and organic nitrocompounds.

AQUATIC TOXICOLOGY: Developed a review of bioaccumulation of xenobiotics in New York Bight biota. Reviewed marine impact data for site designations and special permit applications for marine sewage sludge disposal. Reviewed experimental design and result of laboratory bioaccumulation data.

ANALYTICAL/ENVIRONMENTAL CHEMISTRY: Extensive experience in the use of GC, GC/MS, and TLC in both quantitative and qualitative identification of chemical compounds, including analysis of complex mixtures and environmental samples. Designed automated air monitoring system for remote sampling on hazardous waste sites. Responsible for analytical procedures and equipment start-up for two inhalation toxicology facilities. Experienced in the use of other analytical techniques such as UV-VIS fluoro, IR, NMR, and Raman spectroscopy. Managed the design, engineering, and construction of a mobile automated air monitoring system for measuring organics in air. Designed and constructed automated dynamic gas dilution system.

CARCINOGENESIS: Quantified carcinogenic risks associated with environmental and occupational levels of exposure to chemical carcinogens. Wrote a short evaluation of techniques in quantitative risk assessment of carcinogens. Evaluated a large number of carcinogenesis studies, including NCI bioassays, for validity, reliability of results, and quantification of carcinogenic risk. Contributed a short overview of methods for quantitation of oncogenic risk for an Army standards development report.

MUTAGENESIS: Evaluated a large number of mutagenesis studies, including Salmonella (Ames), Drosophila, yeasts, dominant lethal, and cytogenetic assays. Developed critical evaluation criteria for Salmonella assay with respect to dose-response curves and quantitative corrections for cytotoxicity. Was involved in the start-up of a mutagenicity testing laboratory, including marketing efforts and steering committee. Contributed and evaluated mutagenicity sections of major regulatory support documents.

TERATOLOGY AND REPRODUCTIVE TOXICOLOGY: Conducted research in behavioral teratology on the effect of prenatal exposure to industrial solvents on operant behavior. Critically evaluated teratology and reproductive toxicology studies with specific emphasis on statistics, "biological significance," and confounding factors. Contributed teratology and reproductive toxicology sections for major regulatory support documents. Postulated mechanisms of action for juvenile nasopharyngeal carcinoma.

TOXICODYNAMICS: Extensive experience in performing and evaluating metabolism studies. Made special study of the quantitative interactions of cytochrome P-450 components and their effect on the metabolism of compounds such as PCBs and chlorinated ethylenes. Evaluated and wrote metabolism sections for regulatory support documents. Used metabolism data to determine mechanism of action of specific chemicals.

STRUCTURE-ACTIVITY CORRELATIONS: Compared structural data via matrix analysis to postulate possible common metabolic pathways. Used metabolism data to identify similar mechanisms and intermediates of biotransformation. Used literature and theoretical considerations on mechanisms of biotransformation to postulate effects of untested chemicals. Specific emphasis on the use of structure-activity correlations in the evaluation of carcinogenic and mutagenic properties of chemicals.

INHALATION TOXICOLOGY: Conducted static and dynamic inhalation exposures of animals (rodents) to a variety of organic compounds including chloroprene, vinyl chloride, dichloroethylene, toluene, trichloroethylene, and acetone. Designed and constructed a static inhalation system for the evaluation of the behavioral toxicology of industrial solvents. Performed toxic dynamic studies of inhalation exposure to chlorinated hydrocarbons.

NEUROTOXICOLOGY: Conducted experiments using operant behavior on the behavioral toxicology and teratology of industrial solvents following low-level inhalation exposures. Established dose-response and long-term inhalation criteria for industrial inhalants. Authored neurotoxicology sections for regulatory support documents. Managed the design, engineering, and construction of a mobile automated air monitoring system for measuring organics in air. Designed and constructed automated dynamic gas dilution system.

INFORMATION MANAGEMENT: Designed online Automated Literature Management System for EA. Designed and conducted literature searches on several automated databases. Developed reference sections and methodologies for several assessment and review documents.

EDUCATION:

S.M. (physiology, toxicology), 1979
Department of Physiology
Harvard School of Public Health
Boston, Massachusetts

M.Sc. (biochemistry), 1977
Department of Chemistry
University of Guelph
Guelph, Ontario, Canada

Kandidaats in Chemistry (equivalent of honors B.Sc.), 1975
Subfaculty of Chemistry, Faculty of Science and
Mathematics, University of Amsterdam
Amsterdam, The Netherlands

FOREIGN LANGUAGES:

Dutch, German, and French.

PREVIOUS EXPERIENCE:

ECOLOGICAL ANALYSTS, INC., Sparks, Maryland,	
Scientist, Environmental Toxicology	1981-1983
JRB ASSOCIATES, INC., McLean, Virginia,	
Staff Toxicologist	1979-1981
HOWARD UNIVERSITY, Dept. of Human Nutrition	
and Food, Washington, D.C., Guest Lecturer	Fall 1980, 1981
HARVARD UNIVERSITY MEDICAL SCHOOL, Laboratory	
of Psychobiology, Boston, Mass.,	
Senior Research Assistant	1978-1979
HARVARD UNIVERSITY, Cambridge, Mass.,	
Guest Lecturer	Spring 1978, 1979
HARVARD UNIVERSITY SCHOOL OF PUBLIC HEALTH,	
Laboratory of Toxicology, Boston, Mass.,	
Research Assistant	1977-1978
UNIVERSITY OF GUELPH, Department of Chemistry,	
Guelph, Ontario, Canada,	
Research Assistant	1975-1977
Teaching Assistant	1975-1977

PROFESSIONAL ACTIVITIES:

Air Pollution Control Association
American Association for the Advancement of Science
American Chemical Society
American College of Toxicology
New York Academy of Sciences
Society for Risk Analysis
Society of Environmental Toxicology and Chemistry
Board Member of Chesapeake-Potomac Chapter of the Society of Environmental Toxicology and Chemistry

Conferences/Workshops:

Symposium on Ocean Waste Management:	
Policies and Strategies, University of Rhode	
Island, 2-6 May	1983
Fourth International Ocean Disposal Symposium,	
Plymouth, Devon, England, 11-15 April	1983
Workshop on Low Probability/High Consequence	
Events, Rossyln, VA, June	1982
Meaningful Measures of Marine Pollution Effects,	
Pensacola, Fla., 26-29 April	1982
Design of Sewage Sludge Incineration Systems,	
The Continuing Education Institute,	
Columbia, Md., 22-23 April	1982

International Workshop on the Analysis of Actual vs. Perceived Risks, National Academy of Sciences, Washington, D.C., 1-3 June	1981
Malformations in Developmental Biology, FAES Graduate School, National Institutes of Health, Bethesda, Maryland	1980-1981
Ultrastructural Pathology, FAES Graduate School, National Institutes of Health, Bethesda, Md.	1980-1981
First Annual Conference on Genetic Toxicology and Cytogenetics, Brookhaven National Laboratory, Upton, New York, 25-29 February	1980
Chemical Carcinogenics--Occupational and Environmental, Mt. Sinai School of Medicine, New York, N.Y., 21-23 June	1978
Health Effects of Halogenated Aromatic Hydrocarbons, New York Academy of Sciences, New York, N.Y., 24-27 June	1978

PUBLICATIONS AND PRESENTATIONS:

Plugge, H. 1983. Comparative Risk Assessment. Presented at "Air, Land, and Sea: Which is the best for the disposal of sewage sludge " 28 July 1983. SCCWRP Laboratories, Long Beach, Calif.

Hamner, S. and H. Plugge. 1983. An automated integrated capillary/packaged chromatographic system for mobile ambient air monitoring of volatile organics. Presented at the Third Annual National Symposium on Recent Advances in the Measurement of Pollutants from Ambient Air and Stationary Sources. Research Triangle Park, 3-5 May.

Plugge, H., B. Rubin, and J.J. Gift. 1983. Multimedia risk assessment of sewage sludge disposal alternatives I Generic Methodology. Presented at symposium on Ocean Waste Management: Policies and Strategies. University of Rhode Island, 2-6 May.

Plugge, H., P.A. Cruse, C. Beisser, J. Paull, and B. Rubin. 1983. Multimedia Risk Assessment of sewage sludge disposal alternatives II. Ocean disposal versus incineration - Quantitative Risk Estimates. Presented at Symposium on Ocean Waste Management: Policies and Strategies, University of Rhode Island, 2-6 May.

Rue, W.J., and H. Plugge. 1983. Analyses and Interpretation of New York Bight Bioaccumulation Data. Presented at Symposium on Ocean Waste Management: Policies and Strategies. University of Rhode Island, 2-6 May 1983.

Hamner S., and H. Plugge. 1983. An Automated Air Monitoring System for Volatile Organics. Presented at MASS-APCA Technical Conference on: RCRA and the Clean Air Act: Interaction and Conflicts. Wilmington, Del., 18-19 April.

Plugge, H. and B. Rubin. 1983. Comparative Human Health Cost-Effectiveness Risk Assessment of Air Pollution Control Options. Presented at MASS-APCA Technical conference on: RCRA and the Clean Air Act: Interactions and Conflicts. Wilmington, Del., 18-19 April.

Plugge, H. 1983. Issues in Human Risk Assessment, Chapter 105 in Water Chlorination--Environmental Impact Health Effects, Vol. 4. Ann Arbor Science, Ann Arbor, Mich. (R.L. Jolpy, M.A. Brungs, J.A. Cotruvo, R.B. Cumming, J.S. Mattice, V.A. Jacobs, eds.).

Plugge, H., W.J. Rue, and P.D. Mowery. 1983. Analyses and Interpretation of New York Bight Bioaccumulation Data. Presented at Fourth International Ocean Disposal Symposium, Plymouth, Devon, England, 11-15 April 1983.

Plugge, H. and B. Rubin. 1982. An algorithm for minimizing risk from hazardous waste incineration. Presented at the Workshop on Low Probability/High Consequence Events, Rossyln, Va. June.

Plugge, H., W.J. Rue, and P.D. Mowery. 1982. Interpretation of Marine Bioaccumulation Data. Presented at Meaningful Measures of Marine Pollution Effects, Pensacola, Fla., 26-29 April.

Fava, J.A., J.J. Gift, W.J. Rue, and H. Plugge. 1982. Ocean Dumping Assessment Issues. Presented at Meaningful Measures of Marine Pollution Effects, Pensacola, Fla., 26-29 April.

Gift, J.J., J.A. Fava, G.J. Lauer, H. Plugge, and W.J. Rue. 1982. Briefing on Present Status of Ocean Disposal of Sewage Sludge-Site Designation Rulemaking and Special Permit Application for the City of New York. Presented at meeting of Committee on Merchant Marine and Fisheries, U.S. House of Representatives, Washington, D.C., 26 March.

Plugge, H. and G. Petrazzuolo. 1981. Issues in Human Risk Assessment II. Presented at the Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, Va., 22-25 November.

Plugge, H. 1981. Issues in Human Risk Assessment. Presented at Fourth Conference on Water Chlorination, Pacific Grove, Calif., 18-23 October.

Jaeger, R.J., H. Plugge, and S. Szabo. 1980. Acute bladder toxicity of a polyurethane foam catalyst, NIAX catalyst ESN, containing dimethylaminoproprionitrile. J. Env. Path. Tox. 4:555-562.

Plugge, H. and G. Petrazzuolo. 1980. Nasal Oncogens--A Review. Prepared for Consumer Product Safety Commission under contract CPSC-C-79-1052.

Plugge, H. and R.J. Jaeger. 1979. Toxicology of 2-chloro-1,3-butadiene (chloroprene): acute effects in liver and lung following inhalation exposures in rats. Tox. Appl. Pharm. 50:565-572.

Plugge, H. and R.J. Jaeger. 1979. Toxicology of 2-chloro-1, 3-butadiene (chloroprene): acute effects in liver and lung following inhalation exposures in rats. Presented at Meeting of the Society of Toxicology in New Orleans, La., March 1979.

Plugge, H. 1977. Vinyl chloride: Its biological effects. A review. Master's thesis. University of Guelph. Guelph, Ontario, Canada.

Plugge, H. and S.H. Safe. 1977. Vinyl chloride metabolism: A review. Chemosphere 6:309-325.

Safe, S.H., H. Plugge, B. Chittim, and J.F.S. Crocker. 1977. Analysis of adjuncts used in formulations for the application of organophosphorus pesticides, in Proceedings of the Symposium on Fenitrothion: The Long-Term Effects of Its Use in Forest Ecosystems (J.R. Roberts, R. Greenhalgh, and W.K. Marshall, eds.). NRCCICNRC No. 16073:51-76. National Research Council of Canada.

Safe, S.H. and H. Plugge. 1977. Analysis of an aromatic solvent used in a forest spray program. Chemosphere 6:641-651.

SELECTED REPORTS AND CONSULTING EXPERIENCE:

American Petroleum Institute--Reviewed the human health section of the chromium monograph. Revised State of Michigan's Rule 57 on establishment of water quality criteria. Contributed to cadmium and vanadium monographs.

City of New York--Developed methodologies for the quantitative assessment of human health risks in order to compare the differential risk associated with multimedia disposal of municipal sludge. Performed a multimedia risk assessment of municipal sludge disposal. Briefed congressional staff on issues associated with sewage sludge disposal.

Confidential Clients--Designed stationary air monitoring system for a hazardous waste disposal facility. Prepared an assessment of remedial action for and hazard assessment of PAH contamination soil in a already settled area. Prepared safety plans and monitoring for several hazardous waste sampling activities. Recommended safety plans for excavation of nonsecure landfill cells.

Consumer Product Safety Commission--Managed and developed a review of nasal oncogens based on an extensive review of the world's literature. Disproved the widespread conviction that nasal problems result solely from inhalation of substances.

Electric Power Research Institute--Managed the development of a cost-benefit risk assessment methodology for biofouling control alternatives.

EXXON--Reviewed SNARLs for benzene, toluene, and xylenes. Prepared and delivered expert testimony on health effect of benzene, toluene, and xylenes in ground water.

Haines, Lundbergh and Whaler--Developed a hazard assessment of the health hazards associated with development of PAH contamination ex-industrial site.

Maryland Department of Health and Mental Hygiene--Managed the design, engineering, and construction of an automated mobile air monitoring system including automatic calibration, packed/capillary gas choratography, dual detectors (FID/electrochemical) for each effluent as well as a computerized data system.

National Institute of Occupational Safety and Health--

- Developed the health effects section of special hazard reviews for the di- and trinitrotoluenes with a special emphasis on the general mechanism of action of aromatic nitro-compounds.
- Developed a behavioral inhalation toxicological facility to study the behavioral effects of industrial solvents at low concentrations, and developed dose-response relationships in behavioral toxicology.
- In response to an industrial medical emergency, reviewed the literature and studied the toxicological properties of a polyurethane catalyst.
- Identified a new bladder toxin in rat studies, confirming the causative agent in an occupational setting.

New Hampshire Water Pollution Control Commission--

- Managed the sampling and analysis of the Keefe Environmental Services site lagoon (level B).
- Managed the cost-effectiveness assessment of remedial engineering alternatives at the Keefe Environmental Services site.

New York State Department of Environmental Conservation--Developed safety plan and conducted safety training for site inspection of 20 sites under New York State Superfund. Performed assessment of mitre model scores for chemicals with "unknown" hazards.

Rhode Island Department of Environmental Management--Developed the methodology and performed cost-effectiveness analysis of remedial engineering alternatives at Picillo SUPERFUND Site (NR15) with regard to human health, environmental, social and cost impacts.

U.S. Army--Developed a short review of methods in quantitative oncogenic risk assessment.