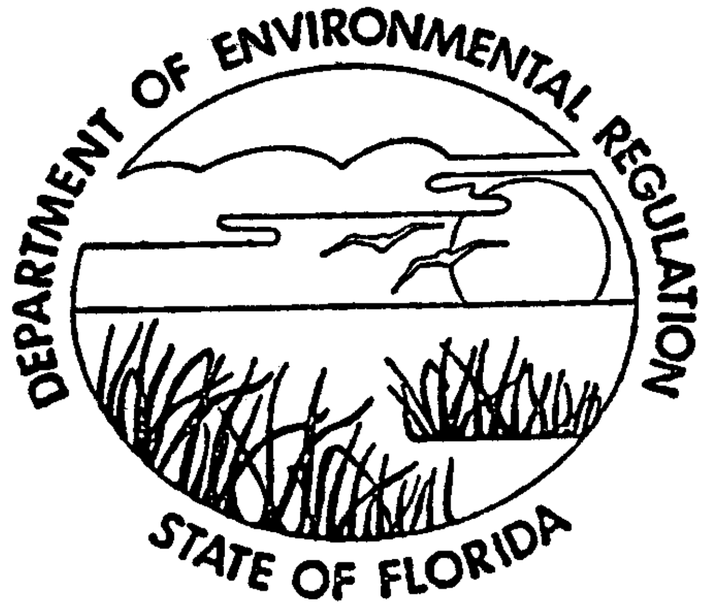


BIOASSAYS OF FLORIDA POWER AND LIGHT

HUTCHINSON ISLAND NUCLEAR POWER PLANTS

SEWAGE TREATMENT FACILITY

ST. LUCIE COUNTY, FLORIDA

NPDES #FL0002208

SAMPLED 5/26/87

JULY 23, 1987

Biology Section
Division of Environmental Programs

BIOASSAYS OF FLORIDA POWER AND LIGHT

HUTCHINSON ISLAND NUCLEAR POWER PLANTS

SEWAGE TREATMENT FACILITY

ST. LUCIE COUNTY, FLORIDA

NPDES #FL0002208

Biology Section
Bureau of Laboratories and
Special Programs
July 23, 1987

EXECUTIVE SUMMARY

Florida Power and Light, Hutchinson Island Nuclear Power Plant's Sewage Treatment Facility, NPDES #FL0002208, on 27 to 29 May, 1987.

The Biology Section performed six separate 48 hour static acute toxicity bioassays on samples of final chlorinated and de-chlorinated recovered waters from the sewage treatment facility of the FPL Hutchinson Island Nuclear Power Plant. The chlorinated sample proved to be acutely toxic to Ceriodaphnia dubia, Daphnia pulex, and to Notropis leedsi, producing 48 hour LC_{50}'s of < 10.0%, 22.4%, and 22.4%, respectively. The total residual chlorine present in this sample (0.8 mg/l) was mostly responsible for this toxicity. The de-chlorinated sample was not toxic to these same test organisms. No ammonia was detected in the sample. Since the toxicity of the sample was apparently due to residual chlorine, further chemical analyses were not performed.

Although these tests adequately evaluate the toxicity of the discharge from the sewage facility, their applicability to state toxicity standards is slight, since the discharge is to the plant's intake canal (cooling water) and not to official state waters. It is believed that the sewage facility's discharge would be substantially diluted by the time it reaches the plant's discharge canal.

INTRODUCTION

The Florida Power and Light Hutchinson Island Nuclear Power Plant is located adjacent to the Atlantic Ocean on Hutchinson Island, St. Lucie County, Florida (Fig. 1). The Plant uses two nuclear fueled units to generate approximately 802 MW of electricity. Cooling water for the nuclear units is obtained from the Atlantic Ocean and is immediately discharged back to the ocean through two 1500' diffuser pipes. The associated sewage treatment facility for the nuclear plant is located near the intake canal just prior to the nuclear units. The facility treats domestic wastes from the plant's employees. Treatment of domestic waste culimates with the addition of chlorine prior to discharge to the intake canal. A schematic of the plant is presented in Figure 2.

At the request of the Southeast District, the Biology Section performed six static acute toxicity bioassays on samples of final chlorinated and de-chlorinated recovered waters from the sewage treatment facility. The tests were performed on 27 to 29 May, 1987. The results are presented in this report. Those involved in performing the tests and in preparation of this report were: J. M. Faircloth, K. M. Lurding, and M. L. Roll.

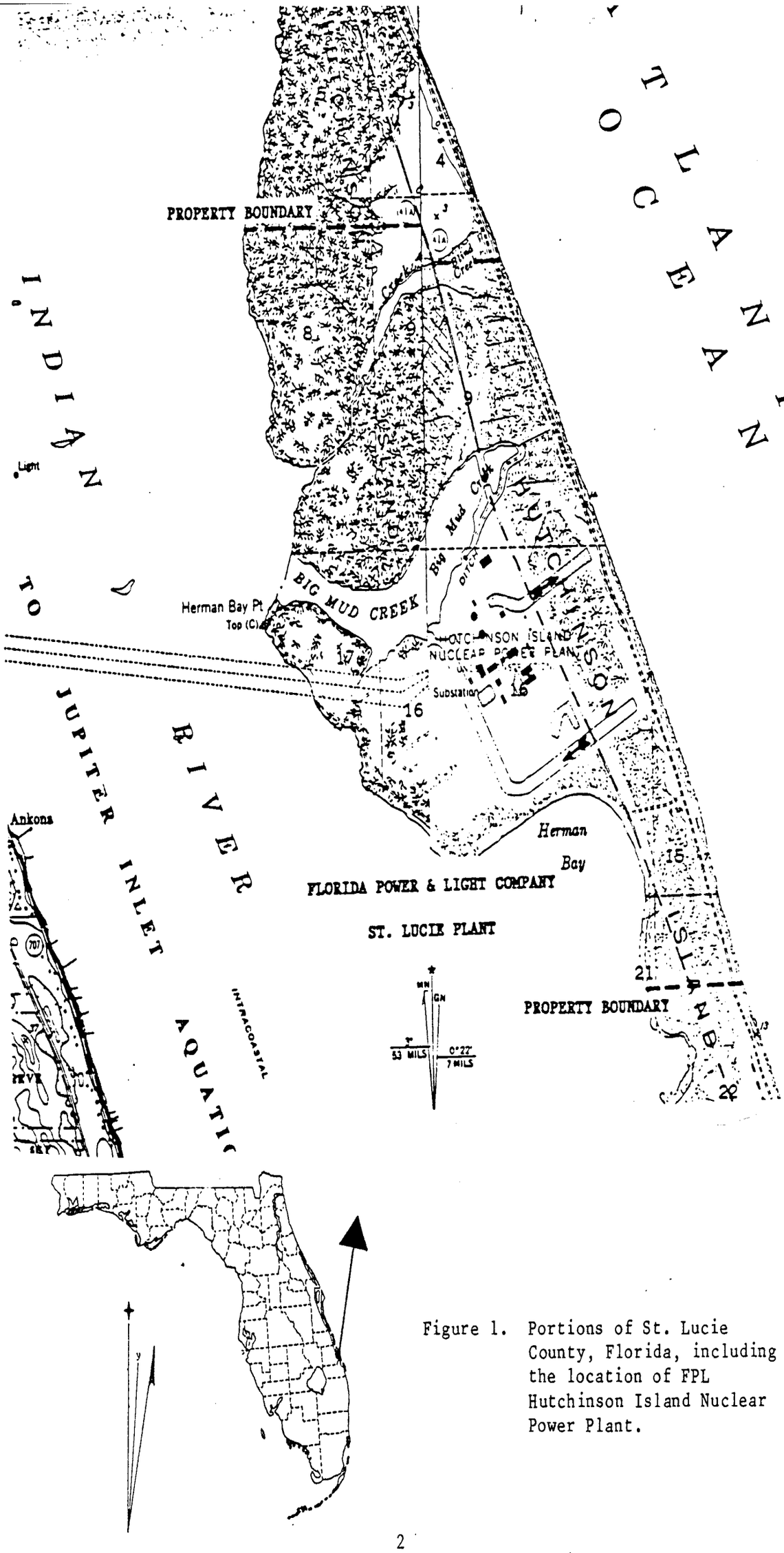
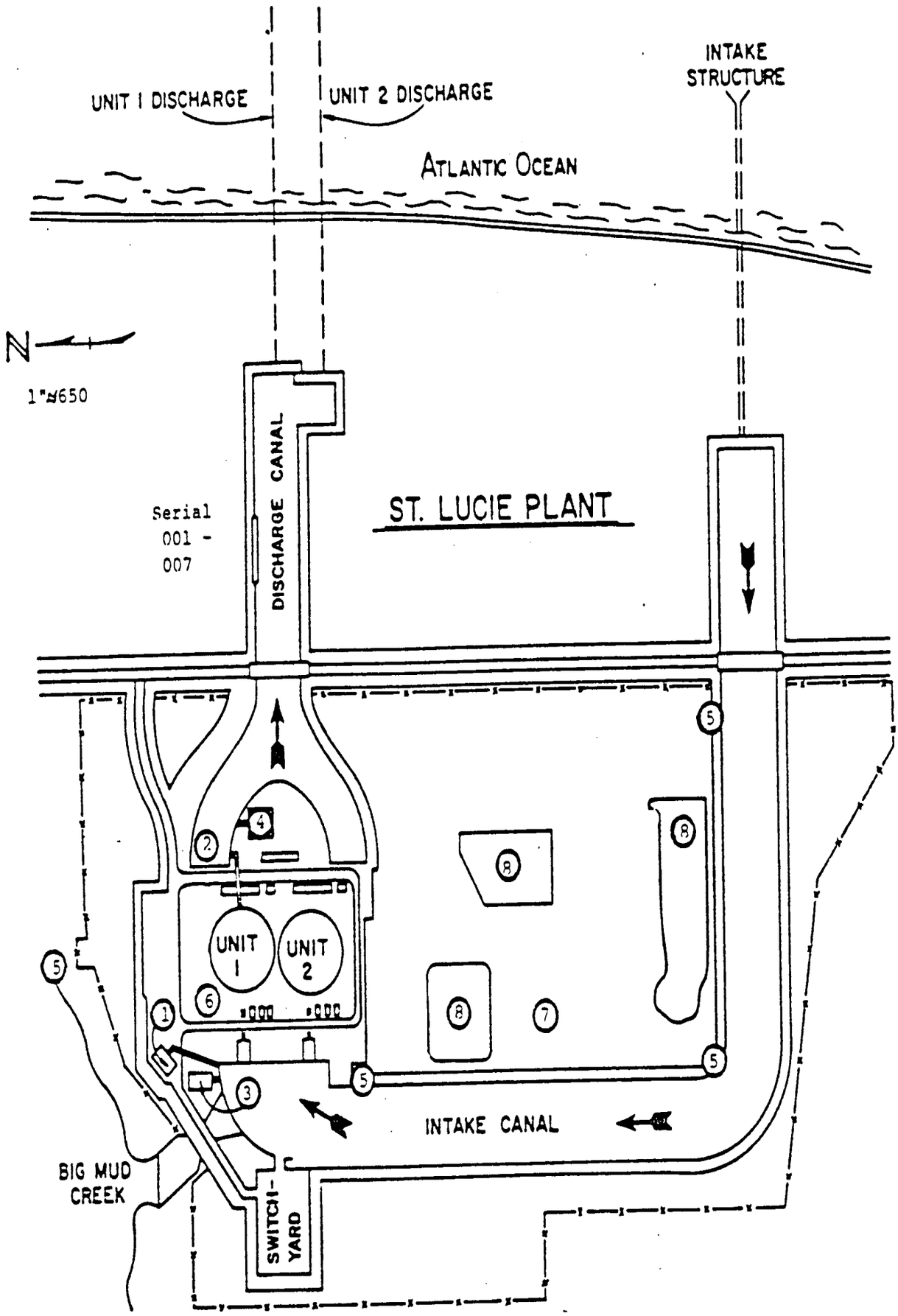


Figure 1. Portions of St. Lucie County, Florida, including the location of FPL Hutchinson Island Nuclear Power Plant.



Legend

1) Low Volume Waste (Neut. Basin) Serial #002
2) Radwaste System Serial #003
3) Unit #1 Sewage Treatment Plant Serial #004
4) Steam Generator Blowdown Serial #005
5) Non-equipment Area Stormwater Drains Serial #006
6) Hazardous Waste Satellite Accumulation Area
7) Hazardous Waste 90-day Accumulation Area
8) Settling Basin

Attachment 2

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier and Weber (1985) and the FDER Biology Section (1985). The organisms selected for this study include species recommended by Peltier and Weber (1985), the U.S. EPA (1978), and the FDER Biology Section (1985). Additionally, the Biology Section maintains cultures of several species of organisms indigenous to the State of Florida. One of these indigenous species was also selected for testing. Life histories of these test organisms and maintenance procedures used to culture them are detailed below.

History and Maintenance of Bioassay Organisms

Daphnia pulex (water flea) - A breeding culture of Daphnia pulex was obtained from the EPA laboratory in Athens, Georgia, in March, 1979. This culture has been maintained since its arrival in 2 1/2 gallon all-glass aquaria, filled with unchlorinated DER well water, under a 16:8 hour light-dark cycle. Organisms are fed a liquified blend of Purina Trout Chow® and Cerophyl® twice daily, once daily on weekends, and are kept at a constant temperature of 22° ± 2°C. The aquaria are cleaned weekly by siphoning off half the water along with the detritus and excess organisms, and then refilling with fresh aerated well water. Additional measures are taken and/or new cultures started in the event of abnormal circumstances such as: declining populations, ephippia formation, or excessive fungal or bacterial growth.

Ceriodaphnia dubia (water flea) - A breeding culture of Ceriodaphnia dubia was obtained from the EPA laboratory in Athens, Georgia, in June, 1985. The culture is maintained in 2-1/2 gallon all-glass aquaria, filled with unchlorinated DER well water, under a 16:8 hour light-dark cycle. Organisms are fed a liquified blend of Purina Trout Chow®, Cerophyl® and Fleischmann's® yeast twice daily, once daily on weekends, and are kept at a constant temperature of 26° ± 2°C. The aquaria are cleaned weekly by siphoning off half the water along with the detritus and excess organisms, and then refilling with fresh aerated well water. Additional measures are taken and/or new cultures started in the event of abnormal circumstances such as: declining populations, ephippia formation, or excessive fungal or bacterial growth.

Notropis leedsi (bannerfin shiner) - Approximately 40 adult bannerfin shiners were obtained from an indigenous population in the upper Suwannee River during October, 1981. The breeding stock is maintained in 30 and 125 gallon all-glass aquaria equipped with a flow-through water exchange system. Water for this system is unchlorinated and is pumped from the DER deep well. The bannerfin shiners are reared at 22° ± 2°C under a 16:8 hour light-dark cycle and are fed Tetra-Min® and frozen Artemia (brine shrimp) twice daily, and once daily on weekends. Breeding and egg hatching are encouraged at 25°C. The eggs are laid between stacked red ceramic tiles separated by a 3mm bead of silicone. Most of the eggs adhere to the tiles and are easily removed to heated, aerated hatching tanks. The narrow space between the tiles eliminates egg predation by adult fish. New hatching tanks are started regularly to segregate fry

into even age groups. Newly hatched fry are fed a liquefied blend of Purina Trout Chow® and Cerophyl® twice daily. After one week, feeding is augmented with newly hatched Artemia nauplii and finely crushed Tetra Min®. The fish used in this test were approximately 27 days old at the time of the test.

To ensure the uniform sensitivity of these test organisms to toxic substances, the Biology Section conducts monthly standard reference toxicant bioassays using sodium lauryl sulfate as the reference toxicant.

Test Methods

Methods used to perform acute toxicity bioassays are described by Peltier and Weber (1985) and the FDER Biology Section (1985). Some of the methods described below are more specific than those of Peltier and Weber. These will be noted in more detail.

Sampling Methods and Test Dates

A total of six separate 48 hour static acute toxicity screening bioassays (50% and 100% concentrations only) were performed on samples of final chlorinated and de-chlorinated recovered waters from the sewage treatment facility of FPL Hutchinson Island Nuclear Power Plant. The tests were performed from 1015 hours on 27 May to 1015 hours on 29 May, 1987.

The samples were collected by Mr. Paul Strauss of DER's Southeast District at 1020 hours on 26 May, 1987, using standard wastewater sampling procedures. Separate samples were obtained for chemical and biological testing. Samples for metal analyses were preserved with HNO_3. Samples for organic chemical analyses and for the bioassays were unpreserved. The samples were iced and transported to the DER laboratory in Tallahassee for analyses within 24 hours of collection.

Test Temperature

Upon arrival of the iced (4°C) bioassay samples in the Tallahassee laboratory, the containers were placed in warm water and the temperature of the samples allowed to rise to 20° $\pm$ 2°C. Although this temperature may be different than the temperature of the sample during collection, it is the temperature range to which the test organisms are acclimatized and is the range recommended in the above referenced bioassay protocols. This avoids stressful effects caused by exposure to unusually cold or warm samples.

Total Residual Chlorine

Since many recovered waters are chlorinated, especially those originating from sewage treatment facilities, it is often desirable to differentiate between the toxicity resulting from chlorine and the toxicity associated with other components of the water. To accomplish this, the Biology Section performed concurrent bioassays on a sample of chlorinated water in which the chlorine had been neutralized. De-chlorination was accomplished by adding a calculated amount of 0.025N

sodium thiosulfate. The total residual chlorine concentrations of the tested samples are given on the bioassay data forms. A comparison of the results of these tests will distinguish between the toxicity due solely to residual chlorine and the toxicity inherently contained in the recovered water.

Freshwater Tests

Freshwater for dilution of the samples was obtained from the same DER deep well that is used to culture the test organisms. The concentration series selected for this study is presented in Table 1.

Two replicates, of each concentration and a control, were used to test with the water fleas, Ceriodaphnia dubia and Daphnia pulex. Flint glass jars of either 60 ml (for C. dubia) or 250 ml (for D. pulex) capacity were used as test chambers, and either 50 ml or 200 ml of the appropriate test concentration was placed in each chamber. Ceriodaphnia were siphoned into a large culture dish and neonates were transferred by glass pipette, and loaded 10 per chamber, resulting in 20 per test concentration. Daphnia were siphoned into a large culture dish to isolate the proper size and age organisms (neonates). To accomplish this, the Daphnia were siphoned through a stainless steel screen. The trapped adults were then discarded. These neonates were then transferred by glass pipette, examined for injury, and were loaded 10 per chamber, resulting in 20 per test concentration. Water fleas were not fed during these tests.

Two replicates, of each concentration and a control, were used for the Notropis leedsi (bannerfin shiner) bioassay. The fish were transferred individually or by twos, into wide mouth quart jars containing 500 ml each of the appropriate test concentration, and were loaded 5 per chamber, resulting in 10 per concentration. Fish were not fed during these tests.

Test Parameters

Dissolved oxygen (YSI Model 57 oxygen meter), pH (Corning Model 7 pH meter with Orion Ross® combination electrode), temperature (NBS calibrated glass thermometer), and the number of live organisms were recorded for each test concentration at 0 hours, 24 hours, and 48 hours. Total alkalinity and total hardness (measured as $CaCO_3$ using HACH Chemical Company reagents) were recorded at the beginning of the test for the controls and the 100% concentration. The specific conductance (YSI Model 33 S-C-T meter) of each test concentration was recorded at the beginning and end of the test. All instruments were calibrated daily according to manufacturer's recommendations. Ammonia concentrations, including the total and unionized fraction (expressed in mg/l as N and as NH_3, respectively), were recorded in the controls and the 100% test concentration at the beginning of the test. Total ammonia concentrations were determined using an Orion® specific ion probe and an Orion Ionalyzer®. The unionized fraction was then calculated based on the total ammonia concentration, and the pH, temperature, and salinity of the sample. These values were recorded on the bioassay data forms and are presented in Tables 2 and 3.

Table 1. Concentration Series and Volumes Used for These Static Bioassays.

Ceriodaphnia dubia (water flea)

Concentration	Dilution Water	Sample	Total Volume
Control	50.0 ml	--------	50 ml
10.0%[a]	45.0 ml	5.0 ml	50 ml
50.0%	25.0 ml	25.0 ml	50 ml
100.0%[b]	-------	50.0 ml	50 ml

Daphnia pulex (water flea)

Concentration	Dilution Water	Sample	Total Volume
Control	200.0 ml	--------	200 ml
10.0%[a]	180.0 ml	20.0 ml	200 ml
50.0%	100.0 ml	100.0 ml	200 ml
100.0%[b]	--------	200.0 ml	200 ml

Notropis leedsi (bannerfin shiner)

Concentration	Dilution Water	Sample	Total Volume
Control	500 ml	--------	500 ml
10.0%[a]	450 ml	50 ml	500 ml
50.0%	250 ml	250 ml	500 ml
100.0%[b]	------	500 ml	500 ml

[a] This concentration was not used in the de-chlorinated tests.

[b] This concentration was not used in the chlorinated tests.

Table 2. Data recorded during 48 hour, *Ceriodaphnia dubia*, *Daphnia pulex*, and *Notropis leedsi*, static acute toxicity bioassays of FPL Hutchinson Island Nuclear Power Plant's Sewage Treatment Facility, NPDES #FL0002208, on 27 to 29 May, 1987.

Chlorinated Sample[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Ceriodaphnia dubia														
Control	10	10	10	8.9	8.9	8.7	8.6	8.4	8.3	20.4	20.5	20.5		
Control	10	10	10	8.9	8.9	8.7	8.6	8.4	8.3					
10.0%	10	10	3	8.9	8.9	8.7	8.4	8.3	8.3	20.3	20.3	20.5		
10.0%	10	7	5	8.9	8.9	8.7	8.4	8.3	8.3					
50.0%	10	0	0	8.5	9.0	-b	8.1	8.3	-b	20.4	20.3	-b		
50.0%	10	0	0	8.5	9.0	-	8.0	8.3	-					
Daphnia pulex														
Control	10	10	10	9.0	9.0	8.5	8.6	8.3	8.3	20.2	20.2	20.3		
Control	10	10	10	8.9	8.9	8.5	8.6	8.3	8.3				205	200
10.0%	10	10	10	8.9	9.0	8.6	8.4	8.3	8.2	20.2	20.2	20.3		
10.0%	10	10	10	8.9	9.0	8.6	8.4	8.3	8.2				310	330
50.0%	10	0	0	8.3	9.1	-b	7.9	8.2	-b	20.2	20.2	-b		
50.0%	10	0	0	8.3	9.1	-	7.9	8 .2	-				850	-b
Notropis leedsi														
Control	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1	21.0	20.2	20.2		
Control	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1				205	205
10.0%	5	5	5	8.6	8.5	7.9	7.9	8.0	8.0	21.0	20.0	20.1		
10.0%	5	5	5	8.6	8.5	7.9	7.9	8.0	8.1				315	320
50.0%	5	0	0	8.2	8.8	-b	7.8	8.0	-b	21.0	20.0	-b		
50.0%	5	0	0	8.2	8.8	-	7.8	8.0	-				850	-b

Control Water

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0

Total Alkalinity 115 (mg/l $CaOO_3$)

Total Hardness 118 (mg/l $CaOO_3$)

100% Sample

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0

Total Alkalinity 126 (mg/l $CaOO_3$)

Total Hardness 160 (mg/l $CaOO_3$)

[a] Total Residual Chlorine: 0.8 mg/l (HACH DPD).

[b] Remaining parameters were not recorded since all organisms were dead by 24 hours.

Table 3. Data recorded during 48 hour, Ceriodaphnia dubia, Daphnia pulex, and Notropis leedsi, static acute toxicity bioassays of FPL Hutchinson Island Nuclear Power Plant's Sewage Treatment Facility, NPDES #FL0002208, on 27 to 29 May, 1987.

De-chlorinated Sample[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Ceriodaphnia dubia														
Control	10	10	10	8.9	8.9	8.4	8.6	8.4	8.4	20.9	20.4	20.5		
Control	10	10	10	8.9	8.9	8.4	8.6	8.4	8.4					
50.0%	10	10	10	8.4	8.9	8.5	8.0	8.3	8.3	20.9	20.4	20.4		
50.0%	10	10	9	8.4	8.8	8.5	8.0	8.3	8.3					
100.0%	10	10	10	7.7	8.9	8.6	7.8	8.3	8.4	21.0	20.5	20.4		
100.0%	10	10	10	7.7	8.9	8.5	7.8	8.4	8.4					
Daphnia pulex														
Control	10	10	10	8.8	8.9	8.2	8.6	8.3	8.3	20.9	20.9	20.5		
Control	10	10	10	8.9	9.0	8.2	8.6	8.3	8.3				205	210
50.0%	10	10	10	8.1	8.9	8.2	7.9	8.2	8.2	21.3	20.4	20.3		
50.0%	10	10	10	8.2	8.9	8.2	7.9	8.2	8.2				850	850
100.0%	10	10	10	7.4	9.0	8.2	7.7	8.2	8.2	21.7	20.3	20.4		
100.0%	10	10	10	7.4	9.0	8.2	7.7	8.2	8.3				1400	1400
Notropis leedsi														
Control	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1	21.0	20.2	20.2		
Control	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1				205	205
50.0%	5	5	5	8.0	8.2	8.7	7.8	8.0	8.1	21.6	20.2	20.1		
50.0%	5	5	5	8.0	8.2	8.7	7.8	8.0	8.1				850	810
100.0%	5	5	5	7.5	8.3	8.7	7.7	8.0	8.1	22.0	20.1	20.1		
100.0%	5	5	5	7.5	8.3	8.7	7.7	8.0	8.1				1400	1390

Control Water

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0

Total Alkalinity 115 (mg/l $CaOO_3$)

Total Hardness 118 (mg/l $CaOO_3$)

100% Sample

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0

Total Alkalinity 126 (mg/l $CaOO_3$)

Total Hardness 160 (mg/l $CaOO_3$)

[a] Total Residual Chlorine: None Detected (HACH DPD).

Table 4. LC_{50} Data for Bioassays of FPL Hutchinson Island Nuclear Power Plant's Sewage Treatment Facility, NPDES #FL0002208, on 27 to 29 May, 1987.

Organism	Method of Data Analysis	24 Hour LC_{50} and 95% Confidence Intervals	48 Hour LC_{50} and 95% Confidence Intervals
Chlorinated Sample			
Ceriodaphnia dubia	Binomial	17.6% (10 and 50)	
	Moving Average	a	< 10.0%, b
	Probit	a	
Daphnia pulex	Binomial	22.4% (10 and 50)	22.4% (10 and 50)
	Moving Average	a	a
	Probit	a	a
Notropis leedsi	Binomial	22.4% (10 and 50)	22.4% (10 and 50)
	Moving Average	a	a
	Probit	a	a
De-chlorinated Sample			
C. dubia	Binomial		
	Moving Average	No Mortality	Random Mortality
	Probit		
D. pulex	Binomial		
	Moving Average	No Mortality	No Mortality
	Probit		
N. leedsi	Binomial		
	Moving Average	No Mortality	No Mortality
	Probit		

[a] Due to an insufficient number of dead organisms, or to the irregular distribution of mortality, an LC_{50} value cannot be calculated using this method of statistical analysis.

[b] The LC_{50} is < 10.0% since more than half the organisms died in the smallest test concentration (10.0%).

RESULTS AND DISCUSSION

The sample of final chlorinated recovered water from the sewage treatment facility of FPL Hutchinson Island Nuclear Power Plant proved to be acutely toxic to Ceriodaphnia dubia, Daphnia pulex, and to Notropis leedsi, producing 48 hour LC_{50},s of < 10.0%., 22.4%, and 22.4%, respectively (Table 4). This toxicity can mostly be atrributed to the total residual chlorine (0.8 mg/1) measured in the sample. The sample of de-chlorinated water was not toxic. No ammonia was detected in the sample. Since toxicity was attributed to residual chlorine, further chemical analyses were not performed.

Since this discharge is to the intake canal and not to official state waters, it is unlikely that a violation of the toxicity standards has or will occur, due to significant dilution in the intake canal.

LITERATURE CITED

Florida Department of Environmental Regulation, Biology Section. 1985. Quality Assurance Manual for Performing Acute Toxicity Tests (Second Edition). FDER.

Peltier, W. and C. I. Weber. 1985. Methods for measuring the acute toxicity of effluents to aquatic organisms (Third Edition). Environmental Research Laboratory. Athens, Georgia. EPA-600/4-85-012. 217 p.

Cl

BIOASSAY DATA FORM

Facility/Toxicant FPL STP

Address St. Lucie Co, Hutch. Is.

NPDES Number

Outfall Number

Test # 1, 2, 3

Type Static-renewal

Organism C. dubia, D. pulex, M. bahia

Sample Collected: Date 5-26-87 Time 1030

Test Beginning: Date 5-27-87 Time 1015

Test Ending: Date 5-29-87 Time 1015

Test Concentration	Chamber Number	Live Organisms 0	24	48	Dissolved Oxygen (mg/L) 0	24	48	pH 0	24	48	Temperature °C 0	24	48	Cond. 0	48	Ammonia Total 0	48	Ammonia Unionized 0	48
control	18	10	10	10	8.7	8.9	8.7	8.6	8.4	8.3	20.4	20.5	20.5	205		0		0	
control	68	10	10	10	8.9	8.9	8.7	8.6	8.4	8.3									
10%	62	10	10	3	8.9	8.9	8.7	8.4	8.3	8.3	20.3	20.3	20.5						
10%	20	10	7	5	8.9	8.9	8.7	8.4	8.3	8.3									
50%	—	10	0	—	8.5	9.0	—	8.1	8.3	—	20.4	20.3	—			0		0	
50%	15	10	0	—	8.5	9.0	—	8.0	8.3	—									
control	38	10	10	10	8.0	9.0	8.5	8.6	8.3	8.3	20.3	20.2	20.3	205	200				
control	4	10	10	10	8.9	8.9	8.5	8.6	8.3	8.3									
10%	20	10	10	10	8.7	9.0	8.6	8.4	8.3	8.2	20.3	20.2	20.3	310	320				
10%	39	10	10	10	8.9	9.0	8.6	8.4	8.3	8.2									
50%	54	10	0	—	8.3	9.1	—	7.9	8.2	—	20.3	20.2	—	950	—				
50%	12	10	0	—	8.3	9.1	—	7.9	8.2	—									
control	63	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1	21.0	20.2	20.2	205	205				
control	44	5	5	5	8.6	8.4	7.6	8.0	8.1	8.1									
10%	46	5	5	5	8.6	8.5	7.9	7.9	8.0	8.0	21.0	20.0	20.1	315	320				
10%	17	5	5	5	8.6	8.5	7.9	7.9	8.0	8.1									
50%	47	5	0	—	8.3	8.8	—	7.8	8.0	—	21.0	20.0	—	950	—				
50%	67	5	0	—	8.0	8.8	—	7.8	8.0	—									

NOTES

Control Water

Total Alkalinity (mg/l $CaCO_3$) 115

Total Hardness (mg/l $CaCO_3$) 118

100% Sample

Total Alkalinity (mg/l $CaCO_3$) 126

Total Hardness (mg/l $CaCO_3$) 160

Age of Test Organisms 27 days

Weight

Instrument Calibrations:

	pH Meter:	D.O. Meter:	S-C-T Meter:
0 Hours	7 at 7, 9 at 9	9.0 at 21°C	10 at 10; 29 at 30
24 Hours	7 at 7 + 9 at 9	9.0 ± 2%	10 at 10; 29 at 30
48 Hours	7 at 7, 9 at 9	9.0 at 21°C	10 at 10; 29 at 30

Cl2 0.8 (HACH)
0.88 (IODOMETRIC)

Reviewed by:

Date: 7/14/87

de-cl

BIOASSAY DATA FORM

Facility/Toxicant FPL STP
Address St. Lucie Co, Hutch Is
NPDES Number
Outfall Number

Test # 4,5,6
Type Static screening
Organism C. dubia, P. promelas, N. Redsi

Sample Collected: Date 5-26-87 Time 1230
Test Beginning: Date 5-27-87 Time 1015
Test Ending: Date 5-29-87 Time 1015

Test Concentration	Chamber Number	Live Organisms 0	24	48	Dissolved Oxygen (mg/L) 0	24	48	pH 0	24	48	Temperature °C 0	24	48	Cond 0	48	Ammonia Total 0	48	Ammonia Unionized 0	48
control	50	10	10	10	9.7	8.9	8.4	7.6	8.4	8.4	20.9	20.4	20.5			0		0	
control	88	10	10	10	9.9	8.9	8.4	7.6	8.4	8.4									
50%	30	10	10	10	9.4	8.1	8.5	7.0	8.3	8.3	20.9	20.7	20.4						
50%	81	10	10	9	9.4	8.3	8.5	7.0	8.3	8.4									
100%	6	10	10	10	9.7	8.9	8.6	7.8	8.3	8.4	21.0	20.5	20.4						
100%	67	10	10	10	9.7	8.9	8.5	7.8	8.4	8.4						0		0	
control	86	10	10	10	9.3	8.7	8.2	7.6	8.3	8.3	20.9	20.7	20.5						
control	14	10	10	10	9.9	9.0	8.2	7.6	8.3	8.3				205	210				
50%	—	10	10	10	9.1	8.9	8.2	7.9	8.2	8.2	21.3	20.4	20.3						
50%	44	10	10	10	9.3	8.9	8.2	7.9	8.2	8.2				950	860				
100%	22	10	10	10	9.4	9.0	8.2	7.7	8.2	8.2	21.7	20.3	20.4						
100%	36	10	10	10	9.4	9.0	8.2	7.7	8.2	8.3				1400	1450				
50%	66	5	5	5	8.0	8.2	8.7	7.8	8.0	8.1	21.6	20.2	20.1						
50%	100	5	5	5	8.0	8.2	8.7	7.8	8.0	8.1				1350	810				
100%	253	5	5	5	7.5	8.3	8.7	7.7	8.0	8.1	22.1	20.1	20.1						
100%	3	5	5	5	7.5	8.3	8.7	7.7	8.0	8.1				1400	1310	0		0	

Instrument Calibrations: pH Meter: D.O. Meter: S-C-T Meter:

0 Hours
24 Hours
48 Hours

NOTES

Control Water

Total Alkalinity (mg/l $CaCO_3$) 115

Total Hardness (mg/l $CaCO_3$) 118

100% Sample

Total Alkalinity (mg/l $CaCO_3$) 126

Total Hardness (mg/l $CaCO_3$) 160

Age of Test Organisms 27 days

Weight

Reviewed by:
Date: 7/14/87

c.dubia
P. pulex
N. Redsi