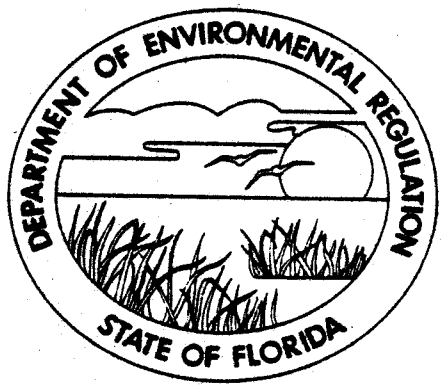


BIOASSAYS OF FARMLAND INDUSTRIES, INC.

BARTOW, POLK COUNTY, FLA.

NPDES #FL0000752

SAMPLED 6/22/81

Biological Section
Bureau of Water Analysis
July 13, 1981

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INTRODUCTION

Farmland Industries is primarily a fertilizer manufacturer operating from the Green Bay Plant on Pebbledale Road, approximately 6 miles southwest of Bartow, Polk County, Florida (Fig. 1). The plant produces various fertilizers, including diammonium phosphate, triple superphosphate and ammonium sulfate, in addition to phosphoric, superphosphoric and sulfuric acids. A uranium recovery plant is also located in the complex. Maximum combined production of these commodities is approximately 7000 tons per day. Raw materials for this production are phosphate rock, sulfur and ammonia.

The complex has two NPDES permitted discharges, #001, consisting of process wastewater that is discharged west of the plant through an unnamed ditch to the North Prong of the Alafia River, and #002, consisting of noncontact cooling water that is discharged east of the plant to Six Mile Creek (Fig. 2). Process wastewater is treated in a holding area (surge pond) where it is neutralized by adding pulverized quicklime to obtain a predetermined pH. The overflow enters a settling pond where the water is raised to a higher pH to complete precipitation of impurities. Overflow from this pond enters a final pond which discharges intermittantly when the facility can no longer maintain surge capacity in the previous retention ponds. This is also dependent on the volume of rainfall. Components of the discharge may include high concentrations of phosphates and fluorides, in addition to radium and other impurities of phosphate rock.

To evaluate the effects of this discharge on the biota of the receiving waters, the Biological Section performed static acute toxicity bioassays on a grab sample from Outfall #001, on 23 to 25 June, 1981. The results of these tests are presented in this report.

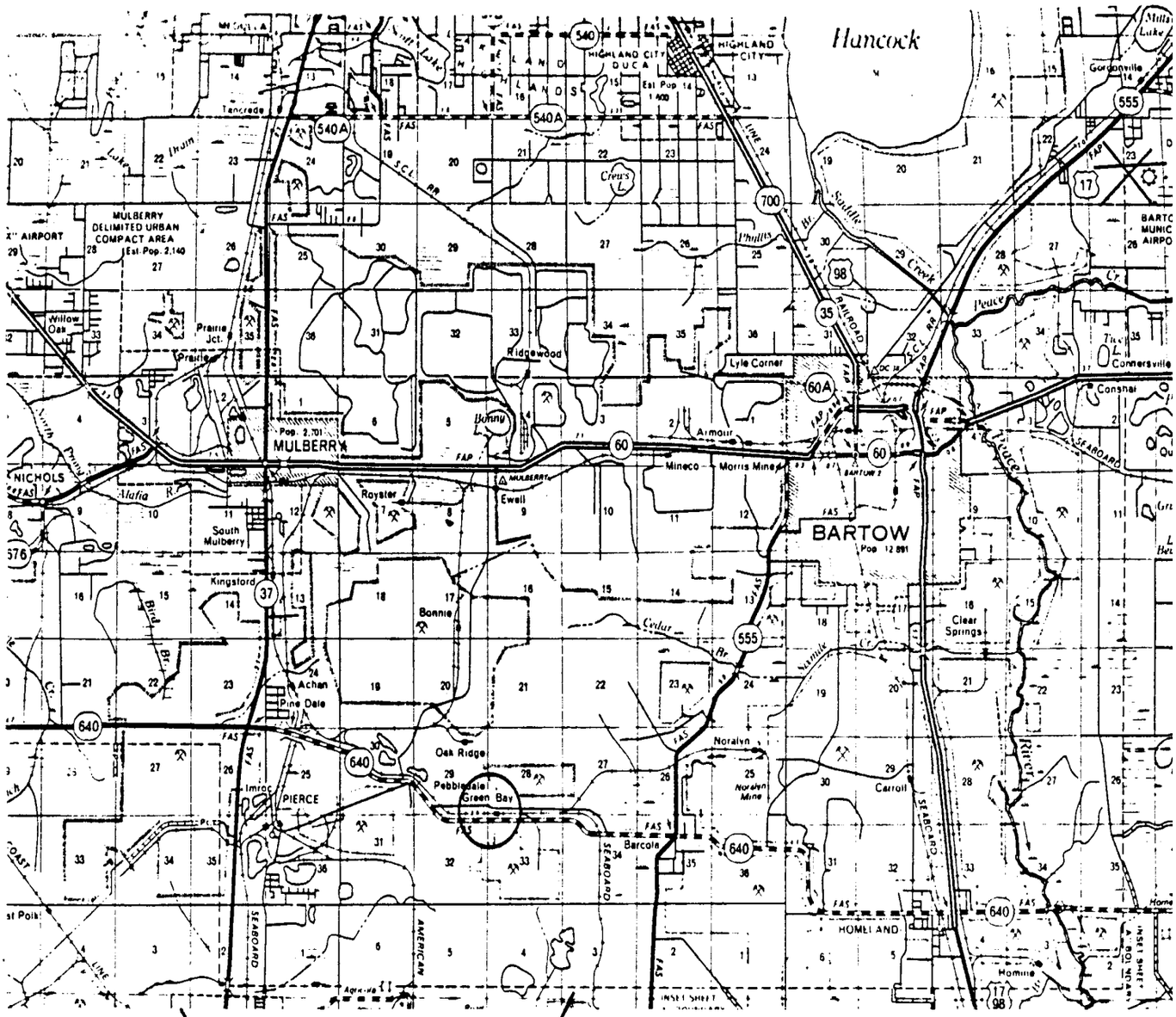


Figure 1. Portions of Polk County, Florida, including Bartow and location of Farmland Industries.

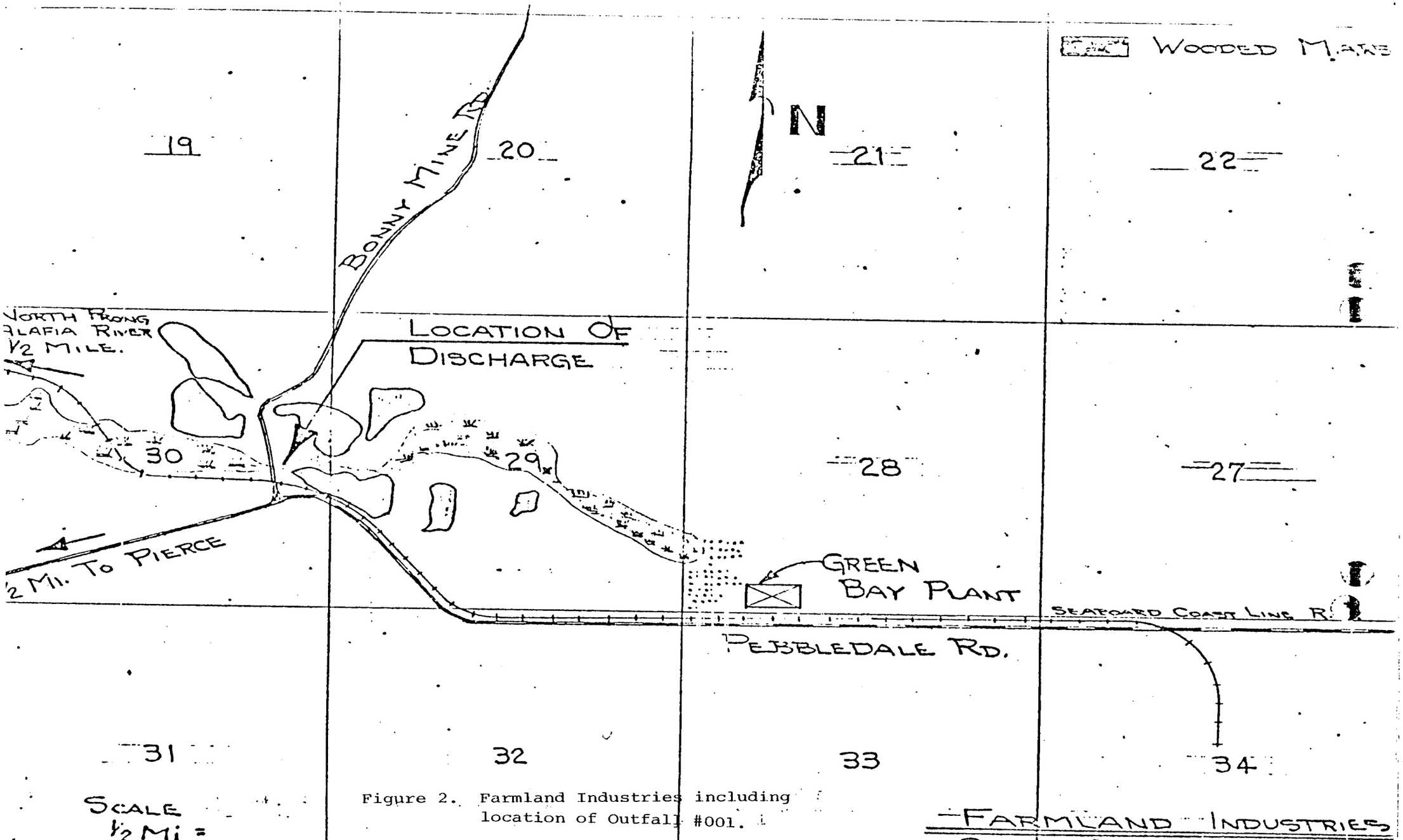


Figure 2. Farmland Industries including location of Outfall #001.

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier (1978). The organisms selected for this study are among those recommended by Peltier (1978) and the U.S. EPA (1978). 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 2½ gallon all glass aquaria filled with unchlorinated DER well water, using a 16:8 hour light-dark cycle. Organisms are fed a liquified blend of Purina Trout Chow® and Cerophyl® twice daily, and are kept at a constant temperature of 22° ± 1°C. The aquaria are cleaned weekly by siphoning off half the water along with the detritus and excess daphnids. They are then refilled 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.

Pimephales promelas (fathead minnows) - A breeding culture of approximately 100 adult fathead minnows was obtained from the EPA laboratory in Cincinnati, Ohio in May, 1979. The fish have been maintained in four 125 gallon all glass aquaria equipped with a flow through water exchange system using unchlorinated well water obtained from a deep well near the DER laboratory. The fish have been reared at a temperature of 22° ± 2°C under a 16:8 hour light-dark cycle. These fish are fed Glencoe Mills Trout Chow® and frozen Artemia (brine shrimp) at a rate of 0.75 g/30 fish, twice daily. Breeding has been encouraged by placing several halved clay pots in each tank to serve as substrates for eggs and to provide cover for the fish. Tanks are examined twice daily (at feeding time) for egg production. Clay pots containing egg clusters are immediately transferred to 15 gallon aerated aquaria for hatching. A new aquarium is prepared for each week's production of eggs, thereby segregating fish into even age groups to be used for testing. After hatching, fathead minnow fry are fed twice daily with freshly hatched Artemia. The fish used in this test were all from 1 to 3 weeks old at the time of the test.

To ensure the uniform sensitivity of these test organisms to toxic substances, the Biological Section conducts monthly Standard Reference Toxicant Bioassays using sodium lauryl sulfate as the reference toxicant.

Test Methods

Two separate 48 hour static bioassays were conducted from 1000 hours on 23 June, 1981, to 1000 hours on 25, June, 1981, on a grab sample of effluent from outfall #001. The sample was collected by Mr. Matt McCann of DER's Southwest District, at 1055 hours on 22 June, 1981, using standard wastewater sampling procedures. The sample was iced and transported to the DER laboratory in Tallahassee within 24 hours of collection.

Freshwater for dilution of the effluent sample was obtained from the same DER deep well that is used to culture the test organisms. The concentration series selected for this study (Table 1) is that recommended by APHA (1976).

Two replicates, each with six concentrations and a control, were used to test with Daphnia pulex. Flint glass jars of 250 ml capacity were used as test chambers, and 200 ml of the appropriate test concentration was placed in each chamber. Daphnia were siphoned into a large culture dish through a stainless steel screen to isolate the proper size and age organisms (neonates). These neonates were then transferred individually by glass pipette and were loaded 10 per chamber, resulting in 20 per test concentration.

Two replicates, of six concentrations and a control, were used for the fathead minnow bioassay. The fish were transferred individually or by twos, by net, into wide mouth quart jars containing 500 ml each of the appropriate test concentration. Fathead minnows were loaded 5 per chamber resulting in 10 per concentration.

Dissolved oxygen, pH, temperature, and the number of live organisms were recorded for each test chamber at 0 hours, 24 hours, and 48 hours. Total alkalinity and total hardness were recorded at the beginning and end of the test for the controls and the 100% effluent concentration. Specific conductance was recorded for each test concentration at the beginning and end of the test. Additionally, ammonia concentrations[1], including total and unionized fractions, were recorded for the controls and 100% effluent concentrations at the beginning and end of the test. These values were recorded on the bioassay data forms and are presented in Tables 2 and 3. Organisms were not fed during these tests.

[1] The total ammonia concentration was determined using an Orion model 95-10 specific ion electrode and is expressed in mg/l as N. The unionized fraction was then calculated based on the total ammonia, pH, temperature and salinity, and is expressed in mg/l as NH_3.

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

Daphnia pulex (water flea)

Concentration	Dilution Water	Effluent	Total Vol.
Control	200 ml	---	200 ml
5.6%	188.8 ml	11.2 ml	200 ml
10.0%	180 ml	20 ml	200 ml
18.0%	164 ml	36 ml	200 ml
32.0%	136 ml	64 ml	200 ml
56.0%	88 ml	112 ml	200 ml
100%	----	200 ml	200 ml

Pimephales promelas (fathead minnow)

Concentration	Dilution Water	Effluent	Total Vol.
Control	500 ml	---	500 ml
5.6%	472 ml	28 ml	500 ml
10.0%	450 ml	50 ml	500 ml
18.0%	410 ml	90 ml	500 ml
32.0%	340 ml	160 ml	500 ml
56.0%	220 ml	280 ml	500 ml
100%	---	500 ml	500 ml

Table 2. Data recorded during 48 hour, *Daphnia pulex*, static acute toxicity bioassay of Farmland Industries, Inc., Bartow, Polk County, Florida. NPDES #FL0000752, Outfall #001. 23 to 25 June, 1981.

Conc. or %	Number of Live Organisms			Dissolved Oxygen (mg/ℓ)			pH			Total Alkalinity (mg/ℓ as $CaCO_3$)		Total Hardness (mg/ℓ as $CaCO_3$)		Temperature (°C)			NH_3/NH_3+NH_4 (mg/ℓ)		Conductivity (μmhos)	
	0	24	48	0	24	48	0	24	48	0	48	0	48	0	24	48	0	48	0	48
Control	10	10	8	8.2	8.6	8.3	7.8	8.0	7.9	113	123	123	119	21.1	19.7	20.8	0/.06	.01/.34	208	215
Control	10	10	9	8.2	8.6	8.4	7.9	8.0	8.0											
5.6%	10	10	9	8.2	8.8	8.8	7.8	7.9	8.0					21.0	19.7	20.6			560	575
5.6%	10	10	10	8.2	8.9	8.9	7.7	7.9	8.0											
10%	10	10	9	8.2	9.3	9.5	7.7	7.9	8.0					21.0	19.6	20.5			805	800
10%	10	10	9	8.2	9.3	9.5	7.7	7.9	8.0											
18%	10	10	8	8.2	9.6	10.0	7.6	7.8	7.9					20.9	19.5	20.4			1280	1200
18%	10	10	9	8.1	9.6	10.2	7.6	7.8	7.8											
32%	10	7	4	8.1	9.9	10.4	7.5	7.7	7.8					20.6	19.6	20.2			2000	1910
32%	10	7	5	8.1	9.9	10.4	7.5	7.7	7.8											
56%	10	1	0	7.8	10.4	10.4	7.4	7.5	7.6					20.1	20.0	20.2			3130	3190
56%	10	2	0	7.8	10.3	10.4	7.4	7.5	7.6											
100%[a]	10	1	0	7.3	10.4	10.2	7.3	7.2	7.3	50	35	816	940	19.5	19.7	20.4	1.53/196[b]	1.64/196	5000	5000
100%[a]	10	0	0	7.3	10.4	10.0	7.3	7.2	7.2											

Remarks:
a. The 100% effluent had a salinity of approximately 3 ppt, and also sustained a considerable algal population.
b. The 196 mg/l total ammonia concentration was calculated through extrapolation, since the millivolt reading corresponded to a number off-scale of the ammonia table.

Table 3. Data recorded during 48 hour, Pimephales promelas, static acute toxicity bioassay of Farmland Industries, Inc., Bartow, Polk County, Florida. NPDES #FL0000752, Outfall #001. 23 to 25 June, 1981.

Conc. or %	Number of Live Organisms				Dissolved Oxygen (mg/ℓ)			pH			Total Alkalinity (mg/ℓ as $CaCO_3$)		Total Hardness (mg/ℓ as $CaCO_3$)		Temperature (°C)			NH_3/NH_3+NH_4 (mg/ℓ)		Conductivity (µmhos)	
	0	5[a]	24	48	0	24	48	0	24	48	0	48	0	48	0	24	48	0	48	0	48
Control	5	5	5	5	8.0	7.5	8.1	7.9	7.8	7.8	113	123	123	119	21.2	19.8	20.4	0/0.6	.02/.51	208	215
Control	5	5	5	5	8.1	7.6	8.1	7.9	7.8	7.9											
5.6%	5	5	5	5	8.2	8.2	9.1	7.8	7.8	8.0					21.4	19.6	20.3			560	550
5.6%	5	5	5	5	8.2	8.2	9.1	7.8	7.8	8.0											
10%	5	5	5	5	8.2	8.2	9.3	7.7	7.8	8.0					21.4	19.4	20.2			805	800
10%	5	5	5	5	8.2	8.3	9.3	7.7	7.8	8.0											
18%	5	5	5	1	8.1	8.9	9.8	7.6	7.7	7.9					21.2	19.5	20.2			1280	1250
18%	5	5	5	5	8.1	9.1	9.8	7.6	7.7	7.9											
32%	5	3	1	0	8.0	9.1	10.0	7.5	7.6	7.8					20.9	19.3	20.0			2000	1990
32%	5	3	1	0	8.1	9.2	10.1	7.5	7.6	7.8											
56%	5	0	0	0	7.7	9.5	10.0	7.4	7.5	7.6					20.3	19.2	20.3			3130	3175
56%	5	1	0	0	7.7	9.5	10.0	7.4	7.5	7.6											
100%[b]	5	0	0	0	7.3	9.5	9.3	7.3	7.2	7.2	50	35	816	940	19.5	19.0	20.1	1.53/196[c]	1.27/196	5000	5000
100%[b]	5	0	0	0	7.2	9.3	9.3	7.3	7.2	7.2											

Remarks: Average weight of fish: 0.0159 g each (average of 10 fish).

a. A count was performed 5 hours into the test since substantial mortality was observed, dead bodies were removed.
b. The 100% effluent had a salinity of approximately 3 ppt, and also sustained a considerable algal population.
c. The 196 mg/l total ammonia concentration was calculated through extrapolation, since the millivolt reading corresponded to a number off-scale of the ammonia tables.

RESULTS AND DISCUSSION

This particular grab sample of effluent from Farmland Industries Outfall #001 proved to be acutely toxic to both Daphnia pulex and to Pimephales promelas. The 24 hour LC_{50}'s for Daphnia pulex ranged from 38.9% to 40.6%, while 48 hour LC_{50}'s were 23.8% to 29.9% (Table 4). The 96 hour LC_{50} would therefore be $\leq$29.9% (Table 4). The toxicity noted in the Pimephales promelas bioassay was both considerable and rapid, resulting in the calculation of a statistically sound 5 hour LC_{50} of from 35.4% to 36.7% (Table 4). The 24 hour LC_{50} was calculated to be 26.7%, while the 48 hour LC_{50} was 19.4% (Table 4). The 96 hour LC_{50} for Pimephales promelas would therefore be $\leq$19.4%.

The toxicity of this effluent may be attributed to the substantial concentrations of total and unionized ammonia found in the sample (Tables 2 and 3). In fact, the total ammonia concentration was so high that it was off the scale of our ammonia table. The unionized fraction of this ammonia was considerably higher than the concentrations that have been found to be toxic to aquatic organisms (U.S. EPA, 1976). Although the effluent was toxic to the organisms tested, it was obviously not toxic to the considerable amount of algae present in the sample. According to Abeliovich and Azov (1976) high concentrations of ammonia inhibit photosynthesis beyond a pH of 7.9. However, because the pH of the sample was 7.3, photosynthesis was apparently able to continue, thus producing the algal bloom. Evidently, the concentration of toxic (unionized) ammonia in the sample, at the relatively low pH of 7.3, was high enough to be fatal to the organisms tested, but not to the particular species of algae in the sample.

Chapter 17-3.051, Florida Administrative Code, indicates that "all waters of the State shall at all places and at all times be free from...components of discharges which...are acutely toxic." "Acute toxicity" is defined in Chapter 17-3.021(1) to mean "the presence of one or more substances...in amounts which are greater than one-third (1/3) of the amount lethal to 50% of the test organisms in 96 hours (96 hour LC_{50})...". In the absence of a mixing zone, this 1/3 of the 96 hour LC_{50} applies at the point of discharge. Chapter 17-4.244(4) states that "in no event shall the maximum concentration of wastes in the mixing zone exceed the amount lethal to 50% of the test organisms in 96 hours (96 hour LC_{50}) for a species significant to the indigenous aquatic ommunity..." This criterion applies at the point of discharge if there is a mixing zone. The distinction between presence or absence of a mixing zone is not relevant here, however, since the testing procedure used does not involve effluent concentration. The 1/3 of the 96 hour LC_{50} criterion is three times as stringent as the 96 hour LC_{50} criterion, and therefore, in the absence of a mixing zone, the procedure used is very lenient. The procedure followed is also lenient in that testing is only done for 48 hours. The 96 hour LC_{50} derived from this testing is therefore reported as "less than or equal to" the 48

hour measurement. The value found after 48 hours can never be more restrictive than the value found after 96 hours. It must be noted that all organisms used in these tests are significant to the indigenous aquatic community since they are sensitive to toxic substances which may be expected to impact the indigenous community.

The toxicity reported here is in excess of allowable limits.

Table 4. LC_{50} Data for Bioassay of Farmland Industries, Inc., Bartow, Florida. NPDES #FL0000752.

Organism	Method of Data Analysis	5 hr. LC_{50} & 95% confidence intervals	24 hour LC_{50} & 95% confidence intervals	48 hour LC_{50} & 95% confidence intervals
Daphnia pulex	Binomial		38.9% (18 and 56)	29.9% (18 and 56)
	Moving Average		40.5% (34 and 48)	23.8% (19 and 30)
	Probit		40.6% (34 and 48)	25.1% (14 and 46) A
Pimephales promelas	Binomial	35.4% (18 and 56)	26.7% (18 and 56)	19.4% (10 and 32)
	Moving Average	36.7% (28 and 50)	B	B
	Probit	36.0% (28 and 45)	B	B

A. Due to the distribution of mortality, results using the probit method are not statistically sound.

B. Due to the irregular distribution of mortality an LC_{50} value cannot be calculated using this method of statistical analysis.

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