

TECHNICAL MEMORANDUM  
March 1984

NORTH NEW RIVER  
BACKPUMPING WATER QUALITY IMPACT STUDY  
REPORT #1  
PRECONSTRUCTION AND INITIAL OPERATION

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## INTRODUCTION

On May 4, 1982 the Department of Environmental Regulation (DER) issued permit number 060535176. The permit allowed for dredging and filling at the western end of the North New River (NNR) Canal necessary for construction of a water supply backpumping facility (G-123) at the S-34 control structure levee on the North New River Canal east of US-27 and north of SR-84. The project involved dredging approximately 500 cubic yards adjacent to the north and south sides of the NNR Canal. The facility will pump water from the canal into Water Conservation Area 3A (WCA-3A) via the NNR Canal, S-142 culverts, and the L-38W borrow canal for water supply purposes when the stage in WCA-3A is well below regulation.

The demands which predicated the construction of G-123 pump station were delineated in a special report written by the Resource Planning Department, SFWMD. The report, entitled, An Analysis of Water Supply Backpumping for the Lower East Coast Planning Area recommended the backpumping of east coast waters into the water conservation area system in order to increase availability of fresh water to meet increasing agricultural and urban demands during periods of low rainfall.

Special condition number four of the FDER permit required that a monitoring program be conducted in water bodies likely to be affected by backpumping operations. This program was to be initiated prior to backpumping and was to extend for a period of at least three years. The sampling regime includes all features outlined in Table 1. The purpose of this data report is to partially fulfill the requirements of this special condition.

TABLE 1. MONITORING PROGRAM FOR NORTH NEW RIVER CANAL BACKPUMPING, WCA-3A

Water Quality		
<u>Sampling Location</u>	<u>Parameters</u>	<u>Frequency</u>
L-38 borrow canal at S-142 discharge and interior sites in WCA-3A marsh. After an initial set of background samples are taken (i.e., before backpumping) sampling stations will be established by dye studies**	Nutrients, major ions, turbidity, alkalinity, BOD, color, temperature, pH, D.O., conductivity	*1/mo. (minimum)
	Diel D.O.	4/yr
	Sediment and water samples-- trace metals, herbicides,	1/yr
Pump Station at G-123	Nutrients, major ions, turbidity, alkalinity, BOD, color, temperature, pH, D.O., conductivity	*1/mo. (minimum)
	Diel D.O.	4/yr
	Sediment and water samples-- trace metals, herbicides pesticides	2/yr (once during backpumping)
L-38 borrow canal, WCA-3A marsh	Dye study	**4 times (under various hydrological conditions)
Eastern basins: NNR Canal - 7 stations C-13 - 3 stations (monitored by Broward County and USGS): At least one additional station will be established east of the control structures on both the NNR and C-13 canals.	Nutrients, major ions, coliforms, D.O., BOD, temp.	1/mo
	Trace metals, pesticides	1/yr

\* Frequency may vary depending upon operation schedules of the pumps. During the first year additional samples will be taken at two week intervals when pumps are in operation.

\*\*Dye studies will be conducted under various hydrological conditions of discharge, flow rates in the L-38W borrow canal, and water levels in WCA-3A, to define areas that are influenced by pump activity. Based on results of the dye study, a transect will be established to represent a gradient of areas that are influenced by S-142 discharges.

## STUDY AREA

The main objective of this data report centers on the newly constructed pump station at G-123 and the potential impact of its discharge waters on WCA-3A. The area of study (Figure 1) includes the western five miles of the North New River and an area of WCA-3A within close range (1 mile radius) of the S-142 culvert. The location of the eight water quality stations represents an attempt to monitor water quality above the G-123 structure, at the structure, in the conveyance culvert below the structure, within the WCA-3A internal canal system, and within the WCA-3A interior marsh. At the time this project was conceived this selection of sampling sites was intended to monitor water quality above, at, and directly below the structure and, additionally, to monitor potentially impacted sites within the marsh.

The land use in the North New River drainage basin is medium to high density urban in the eastern portion, but in the western portion it is mostly pastureland with one large medium density urban development, Bonaventure, on the south. Most of the excess water from the land to the south of the NNR canal drains south away from the NNR, with the exception of the Bonaventure development. The western half of the NNR Canal is bordered on the north by the L-24 levee which forms the southern impoundment levee in WCA-2B. Seepage through this levee is considered to be high (Waller, 1978) and thus may strongly influence the water within this section of the NNR.

The Middle River Canal (C-13) can flow directly out to tidewater (S-36) or may, under certain hydrologic conditions, flow into the NNR Canal. For this reason it is considered to be part of the NNR drainage basin.

The C-13/North New River basin is under significant pressure for development which will undoubtedly escalate when I-75 is completed. The

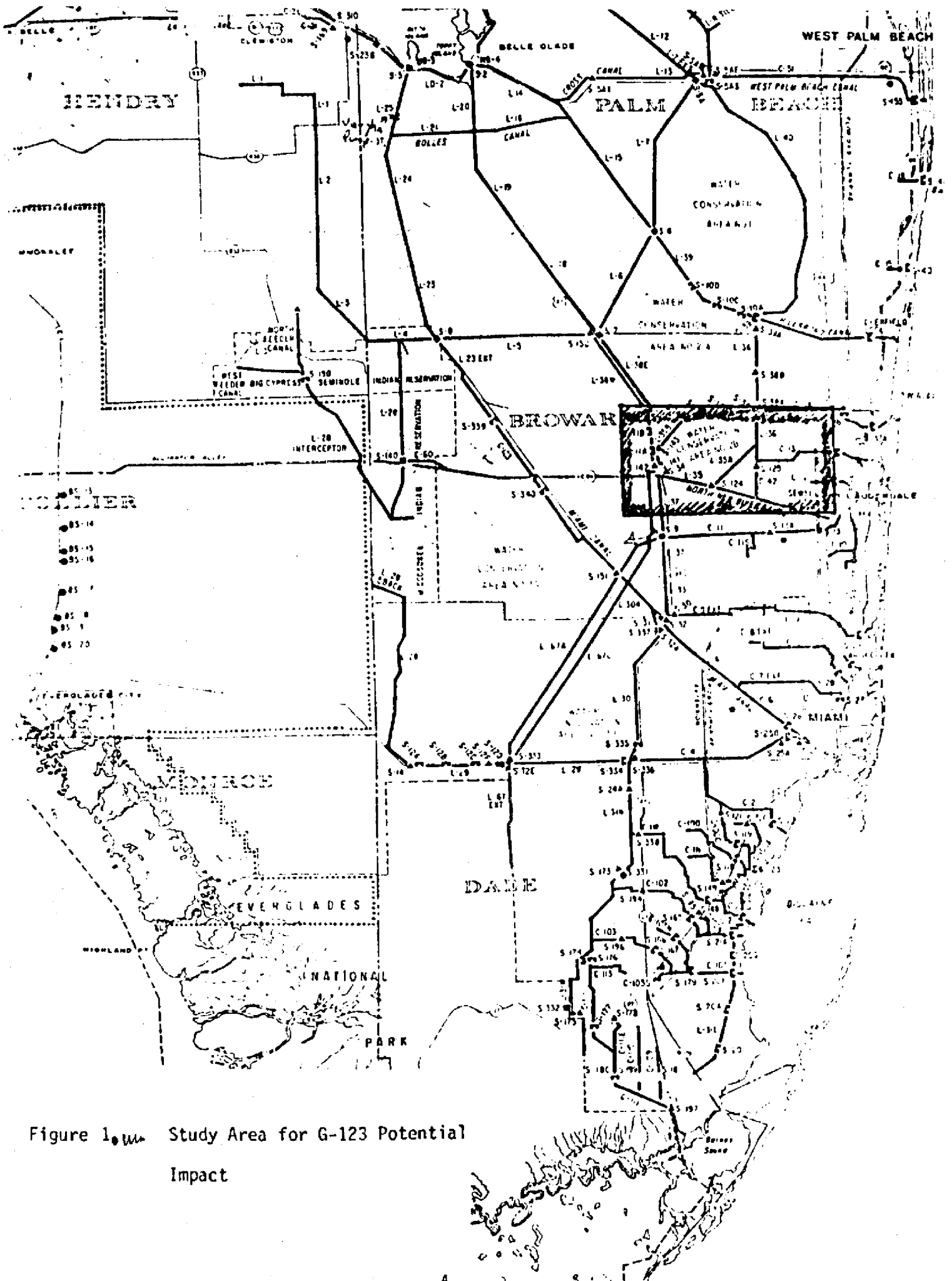


Figure 1. Study Area for G-123 Potential Impact



recent construction of a large I-75 interchange where US27 meets Alligator Alley, and the resultant potential escalation of development, may have a significant effect upon the future water quality within this study area.

The WCA-3A marsh, in the vicinity of the G-123 discharge (specifically the south east portion of that portion of WCA-3A north of Alligator Alley), is generally described as disturbed Everglades habitat. Physically the area is bordered on two sides by drainage canals, punctuated by a series of perpendicular finger canals, constructed in order to access high voltage transmission towers. In addition to being overdrained, the area is also impacted by S-11 discharges which are nutrient enriched (Millar, 1983). As a result of these two influences the area is dominated by cattails (*Typha*) and willow (*Salix*), two indicators of a highly disturbed Everglades habitat.

Average annual rainfall in this area ranges from 54-60 inches per annum. According to hydrologic studies, the relationship between accumulated rainfall and runoff indicates that annual runoff is only slightly less than annual rainfall (which indicates that almost all rainfall within the area is discharged to tide water). It was partially based on this observation that the pump station at G-123 was constructed to backpump some of this excess water into WCA-3A for future needs.

## HISTORICAL WATER QUALITY

General water quality within the NNR drainage basin has been routinely monitored by the Broward County Environmental Quality Control Board (BCEQCB). Their sampling network includes seven water quality sites on the NNR and three along C-13. All sites are west of the salinity control structures and east of the WCA's.

A review of BCEQCB data for the six year period 1975-80 was documented in SFWMD special report, An Analysis of Water Supply Backpumping for the Lower East Coast Planning Area (February 1982). The data indicated that, in general, phosphorus and nitrogen levels within the C-13/NNR drainage basin were relatively low. Average phosphorus concentrations varied only slightly among the seven stations, from 0.03 mg/L to 0.06 mg/L during the six years. The average total nitrogen for this period also demonstrated little variation, from 1.12 mg/L to 1.37 mg/L.

Average dissolved oxygen levels within these two canals has been consistently low, ranging from 1.6 to 3.8 mg/L, well below the FAC Chapter 17-3 state standard of 5.0 mg/L. Within these drainage canals dissolved oxygen levels decrease from east to west, perhaps indicating an increase in groundwater influence within the western reaches.

The BCEQCB also routinely collected both fecal and total coliform data. All stations demonstrated total coliform counts in excess of state standards (2,400 MPN) during one or more months of that study. Total coliform levels at two stations exceeded state standards in 8% of the samples collected. Additionally, three of the seven NNR stations exceeded state standards for fecal coliforms (800 MPN) in 3% of the samples collected. Coliform

concentrations showed no consistent trends from east to west within the NNR/C-13 drainage basin.

A previous study done by this agency on NNR water quality (Lutz, 1977) also concluded that both total nitrogen and total phosphorus concentrations in the NNR were relatively low.

## MATERIALS AND METHODS

### Sample Site Locations

Water quality sampling sites are shown in Figure 2. Locations are described in Table 2.

### Sample Collection and Frequency

Parameters and sampling sites were selected in order to address the special conditions of the DER permit.

Surface water quality samples were collected during two time periods; (1) before construction and (2) during discharge activity. The sampling dates are summarized below:

<u>Before Construction</u>		<u>During Discharge</u>
2/25/82	3/26/82	12/14/82 (G-123 only)
3/1/82	4/2/82	12/28/82 (G-123 only)
3/5/82	4/12/82	1/6/83
3/22/83	5/14/82	1/17/83
	6/23/82	

Physical data (temperature, dissolved oxygen, conductance, and pH) were recorded with a Hydrolab (R)8000. Water samples were bottled, filtered (where applicable), stored on ice, and delivered to the water chemistry laboratory for analysis the following week. Routine laboratory analyses included:

Nutrients	Cations
Turbidity	Color
Total Suspended Solids	Total Organic Carbon
Chlorides	Alkalinity
Hardness	Trace Metals

All analytical methodologies are provided in Appendix A.

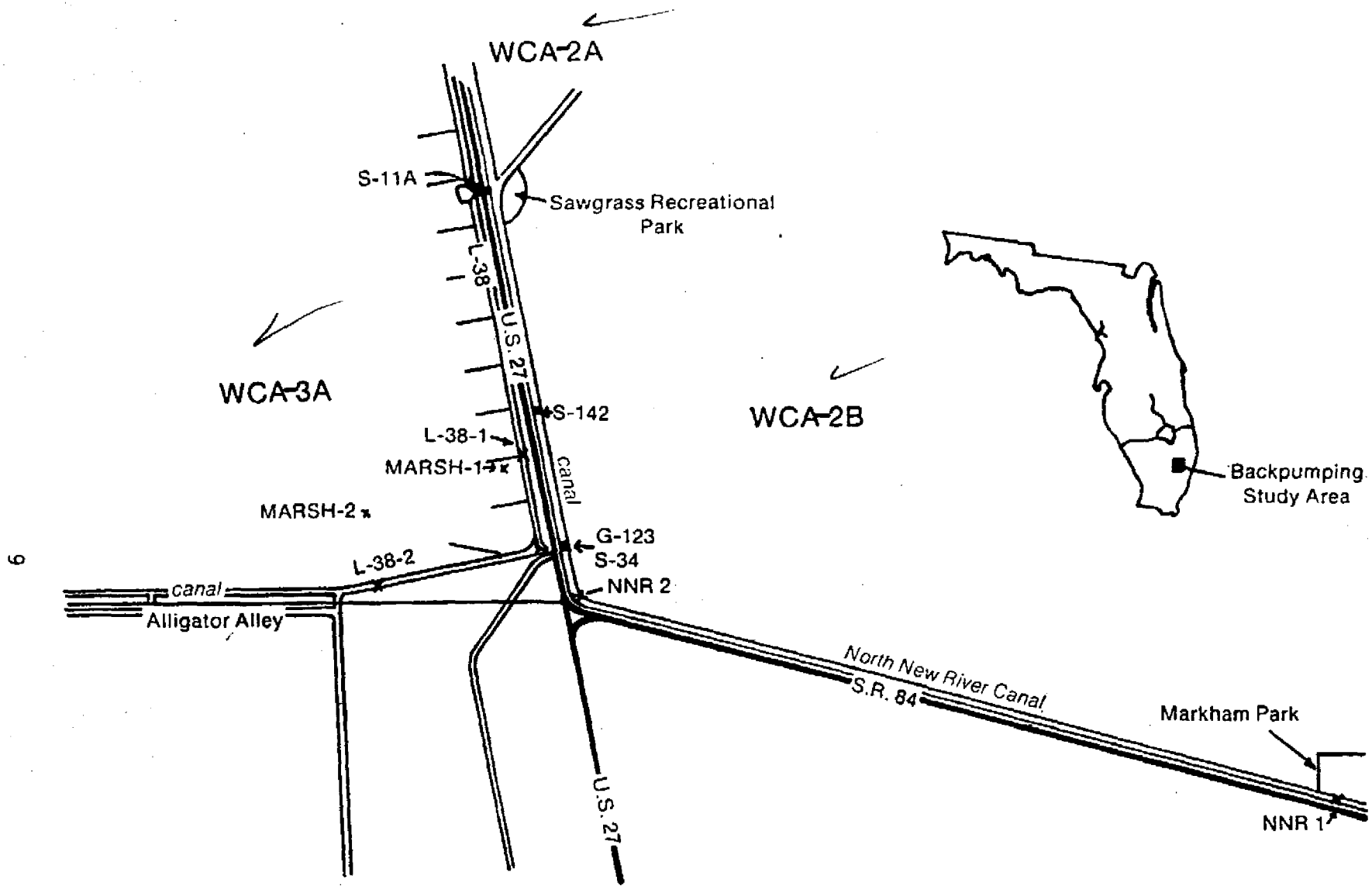


Figure 2. Sample Site Location for North New River (G-123) Backpump Study

TABLE 2. STATION CODES AND LOCATIONS

<u>Stations</u>	<u>Locations</u>
NNR1	In the North New River Canal at the entrance to Markham Park. About 5 miles upstream (East) of G-123.
NNR2	About 250 yds. upstream of G-123 in the North New River Canal.
S-142	One mile downstream of G-123 in the North New River Canal.
L38-1	In the L-38 Canal of WCA-3A about 0.25 of a mile downstream of S-142.
L38-2	In the L38 Canal of WCA-3A about 1.75 miles downstream of S-142.
MARSH-1	In the marsh 100 yds. west of L38-1.
MARSH-2	In the marsh about one mile west of MARSH-1.
G-123	Directly upstream (south) of the structure.

### Dissolved Oxygen

In addition to in situ dissolved oxygen readings taken during sampling trips, diel dissolved oxygen and temperature data was collected at several sites using a YSI dissolved oxygen monitor. All readings were taken hourly at a depth of 0.5 meters. Dates and locations of diel dissolved oxygen data were:

1. Before Completion (1982)

3/1 - 3/5 ----- S-142, L38-1, MARSH-2

3/22 - 3/26 ----- MARSH-2

4/2 - 4/9 ----- NNR2

4/12 - 4/16 ----- L38-1

5.10 - 5/14 ----- L38-2

2. During Discharge (1983)

1/6 - 1/13 ----- MARSH-2

### Trace Metals, Pesticides, Herbicides, etc.

Twice during this report period, trace metal data were collected from selected stations within the study area. On 3/22/82, sediment and water samples for trace organic, trace metal, and other special analyses were collected at stations NNR2, L38-1, and Marsh-2. The parametric coverage on these sediment and water samples was extensive: chlorinated hydrocarbons, poly-chlorinated biphenyls (PCB), biochemical oxygen demand (BOD), coliforms, and oil and grease (BOD, coliforms, oil and grease analyzed in water samples only). All analyses were performed by Everglades Laboratory, Inc., West Palm Beach, Florida.

On 3/26/82 additional water samples were collected from all sample sites except MARSH-1 and analyzed by the SFWMD laboratory for arsenic, cadmium, copper, lead, mercury, and zinc.

These analyses for trace metal, trace organic, etc. were repeated on additional samples collected January 6, 1983.



## RESULTS

The results of mean water chemistry data for the eight sampling sites are presented in Table 3. The data are organized as to no flow (preconstruction) versus flow (discharge) conditions and will be discussed in the following sections.

### Pre-construction

Water sampling during this period extended from February to June 1982 representing the time period previous to completion of the G-123 pump station. It should be noted that, despite construction safeguards, the water quality nearest to the pump site (S-34 and G-123) may have been influenced by District construction activity or the more extensive nearby highway construction.

There were some strong areal differences in general water quality among the eight sampling sites, which will be highlighted by parameter.

### Dissolved Oxygen and Specific Conductivity

Dissolved oxygen levels were highest at MARSH-1, averaging 7.0 mg/L for the pre-backpumping period, and lowest at NNRI, averaging 3.4 mg/L. This was to be expected. These dissolved oxygen readings were all taken during daylight hours when dissolved oxygen levels within the marsh would be at their highest. Station NNRI, however, is a canal station and generally representative of the water within the North New River which, as previously stated, is generally low in dissolved oxygen. It might be noted here that Waller (1978) noted a high degree of seepage through the L-35 levee which divides WCA-2B from the NNR Canal. Thus, it can be concluded that the water in that reach of the NNR Canal may be strongly reflective of WCA-2B seepage.

TABLE 3. COMPARISON OF GENERAL WATER QUALITY AT G-123 SAMPLING SITES BEFORE AND DURING DISCHARGE

	<u>DO</u>		<u>Cond.</u>		<u>Turb.</u>		<u>Color</u>		<u>TSS</u>	
	No <sup>1/</sup> Flow	2/ Flow	No Flow	Flow	No Flow	Flow	No Flow	Flow	No Flow	Flow
NNR1	4.4	2.0	963	803	3.5	3.0	73	103	3.5	3.5
G123	4.3	1.5	1068	845	2.6	1.8	94	83	-	2.0
L38-1	6.3	2.9	1300	881	3.1	3.4	117	106	5.3	2.7
L38-2	6.7	2.9	1167	892	3.4	2.2	105	110	7.2	2.3
NNR2	3.4	2.5	1029	854	2.1	4.2	86	73	10.0	5.3
S142	5.3	1.4	950	838	5.0	2.8	73	72	7.6	3.5
MARSH1	7.0	3.3	1159	888	2.5	1.7	135	113	9.7	2.5
MARSH2	3.8	1.7	924	920	5.4	0.7	126	116	13.8	2.7

	<u>Inorganic Nitrogen</u>		<u>Total Nitrogen</u>		<u>NO<sub>x</sub></u>		<u>NO<sub>3</sub></u>		<u>NH<sub>4</sub></u>	
	No Flow	Flow	No Flow	Flow	No Flow	Flow	No Flow	Flow	No Flow	Flow
NNR1	0.61	0.53	2.46	2.10	.025	.010	.008	.006	.60	.65
G123	0.59	0.70	2.80	2.05	.090	.004	.018	.004	.50	.70
L38-1	0.67	0.27	3.53	2.28	.600	.025	.037	.006	.07	.45
L38-2	0.58	0.20	3.27	2.22	.516	.045	.032	.008	.07	.30
NNR2	0.51	0.58	2.81	1.98	.050	.004	.009	.004	.46	.79
S142	0.41	0.72	2.53	2.03	.095	.008	.010	.004	.32	.72
MARSH1	0.01	0.19	2.36	2.13	.005	.100	.004	.009	.01	.21
MARSH2	0.37	0.02	3.48	2.28	.069	.004	.010	.004	.30	.01

<sup>1/</sup> no flow - 1/1/82 - 6/22/82

<sup>2/</sup> flow - 12/1/82 - 1/30/83

TABLE 3. (Continued)

	<u>Na</u>		<u>Ca</u>		<u>Mg</u>		<u>K</u>			
	<u>No 1/ Flow</u>	<u>2/ Flow</u>	<u>No Flow</u>	<u>Flow</u>	<u>No Flow</u>	<u>Flow</u>	<u>No Flow</u>	<u>Flow</u>		
NNR1	86	67	84	73	18	11	3.14	3.01		
G123	105	71	82	75	24	13	6.90	2.95		
L38-1	135	84	93	74	33	18	7.42	4.31		
L38-2	113	87	90	72	29	20	7.03	4.83		
NNR2	96	71	85	75	23	13	5.16	2.86		
S142	92	74	77	76	23	13	5.89	2.92		
MARSH1	120	86	77	72	29	20	5.75	4.89		
MARSH2	91	94	74	68	24	24	5.85	6.61		

	<u>OP<sub>4</sub></u>		<u>TP<sub>4</sub></u>		<u>Cl</u>		<u>Alk</u>		<u>Hard.</u>	
	<u>No Flow</u>	<u>Flow</u>	<u>No Flow</u>	<u>Flow</u>	<u>Flow</u>	<u>No Flow</u>	<u>Flow</u>	<u>No Flow</u>	<u>Flow</u>	<u>Flow</u>
NNR1	.010	.004	.020	.013	126	99	5.24	4.79	284	233
G123	.004	.004	.032	.006	149	105	5.25	5.23	303	243
L38-1	.016	.004	.055	.016	178	114	6.05	4.64	367	241
L38-2	.015	.004	.055	.019	162	118	5.83	4.63	344	243
NNR2	.004	.004	.028	.017	140	105	5.50	5.02	307	231
S142	.005	.004	.023	.006	137	104	4.90	5.32	286	244
MARSH1	.004	.004	.019	.026	170	116	5.19	4.46	312	239
MARSH2	.051	.004	.127	.014	134	124	5.19	4.42	281	248

There was no definitive east to west trend for specific conductivity within the study area. The two perimeter canal marsh stations (L38-1 and L38-2) and a marsh interior station (MARSH-1) exhibited high average conductance levels, 1300, 1167, and 1159  $\mu\text{mhos/cm}$ , respectively. The lowest mean conductance, however, was also recorded for a marsh interior station, MARSH-2 (924  $\mu\text{mhos/cm}$ ).

#### Turbidity, Color, Total Suspended Solids

Average preconstruction turbidity levels were low with a range of 2.3 NTU at NNR2 to 5.4 NTU at interior marsh site MARSH-2. Similarly, color levels were also highest at the interior marsh stations, 135 units and 126 units at MARSH-1 and MARSH-2, respectively. Levels decreased with no obvious areal trend to a low of 73 units at both NNR1 and S-142. Like turbidity, total suspended solids were also highest at MARSH-2 (13.8 mg/L). The range for total suspended solids was greater than any other parameter discussed thus far in that NNR1 was characterized by a low level of 3.5 mg/L.

#### Macronutrients

Preconstruction means for total nitrogen ranged from a low of 2.36 mg/L at MARSH-1 to a high of 3.53 mg/L at L38-1. Similarly inorganic nitrogen also was highest at L38-1 (0.67 mg/L) and lowest at MARSH-1 (0.01 mg/L). It is interesting to note that these two extreme stations were within 100 yards of each other.

Both ortho and total phosphorus levels were greatest at MARSH-2, 0.051 mg/L and 0.127 mg/L, respectively. Again levels were lowest for both parameters at site MARSH-1, 0.004 mg/L and 0.019 mg/L for ortho and total phosphorus, respectively. Ortho to total phosphorus ratios varied little averaging .30 to .40 for all sites.

### Chloride, Hardness, and Alkalinity

All three of these parameters exhibited similar results. Marsh perimeter canal station L38-1 displayed the highest preconstruction means for all three parameters; 178 mg/L, 367 mg/L and 6.05 mg/L, respectively. The other interior canal site L38-2 and site MARSH-1 were also characterized by high levels of these indices. Again, the more interior of the two marsh stations (MARSH-2) exhibited relatively lower levels of these three indices.

### Preconstruction Conclusion

Although the period of study and number of observations were limited several trends did appear.

The sampling site which most consistently exhibited low levels of most water chemistry indices was site NNR1. Conversely, those stations which were high in most parameters were the two (L38-1 and L38-2) located in the WCA-3A L-38 perimeter canal. Due to the geophysical makeup of the WCA-3A interior canals, these stations may be strongly influenced by discharges from the S-11 structures to the north. During the pre-construction period, January-June 1982, the S-7 pump station discharged over 118,000 acre-feet of water into WCA-2A. During this same time period the three S-11 structures were also open, discharging over 105,000 acre-feet of water. During periods when both structures are operating, S-11 discharge waters have been shown to be highly impacted by S-7 (Millar, 1983), reflecting relatively high nutrient and mineral content of the agricultural runoff pumped by the S-7 pump.

Stations G-123 and NNR2 are geographically close and, with the exception of inorganic nitrogen, share very similar water qualities. To better highlight the similarities and differences between stations a Pinkman and Pearson cluster analysis was run on all eight stations utilizing five major parameters: total nitrogen, total phosphorus, chloride, conductance, and

turbidity. For these selected parameters three groups of highly similar pairs emerge at a similarity coefficient of 0.70 (Figure 3); 1) G-123, NNR2, and MARSH-1, 2) L38-1 and L38-2, and 3) NNR1, MARSH-2, and S-142. The sites in each group are considered to be most similar among themselves in regard to these five forementioned water quality indices. Two of the pair sets are geographically close; L38-1/L38-2 and G123/NNR2. Oddly enough the two sample sites with the highest coefficient of similarity (0.90) are NNR1 and S-142, some 5½ miles apart.

DENDROGRAM PLOT NUMBER 1  
 CLUSTER ANALYSES TN TP CL COND TURB  
 USING PINKHAM AND PEARSON COEFFICIENT OF ASSOCIATION,  
 0-0 MATCHES EQUAL ONE  
 GROUP SIZE UNIMPORTANT

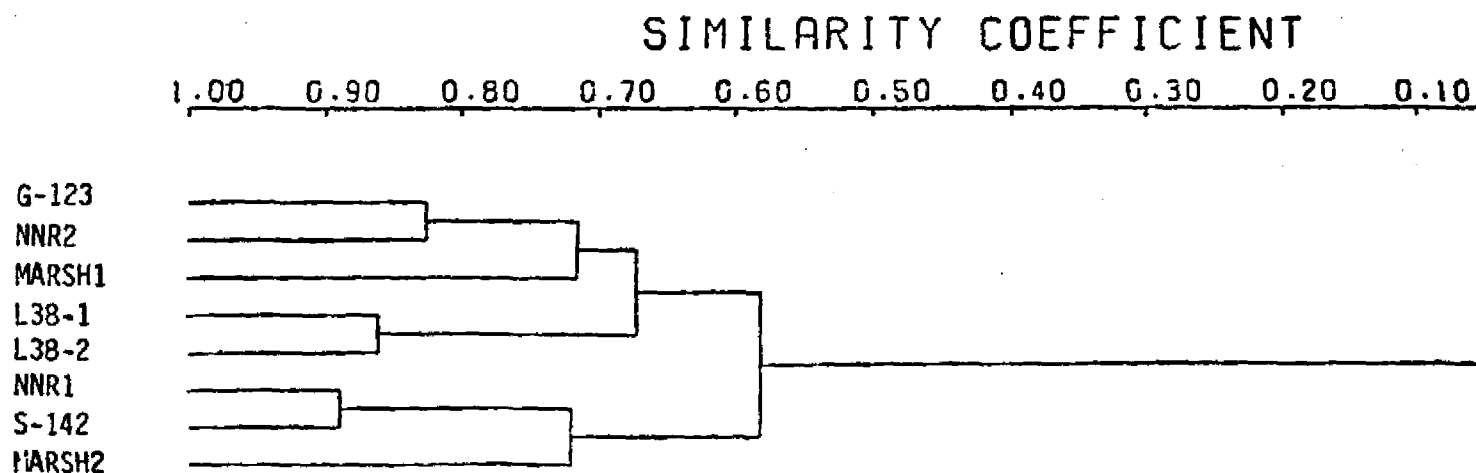


Figure 3. Cluster Analysis of G-123 Sampling Sites for Selected Water Chemistry Parameters

### During Discharge

On June 16, 1982 the G-123 pump station was completed and a short period of discharge activity was initiated. This activity was predicated more by a need for pump testing and to establish discharge curves than any water supply considerations. Pumping activity during this two week period was erratic and constantly fluctuating.

In December of 1982 the pumps were again activated, this time for water supply purposes. In all, over 15,000 acre-feet were pumped; approximately 10,000 acre-feet from December 14, 1982 to December 29, 1982 and 5,000 acre-feet between January 17 and 25, 1983.

As mentioned in the Materials & Methods section, two water sampling trips were conducted during this discharge period; 1/6/83 and 1/17/83. The means of those separate water quality analyses are also presented in Table 3.

In general those areal trends noted for the sampling sites before construction were still evident during discharge; low parametric levels at NNR1, and similarly between stations NNR2 and G-123 and strong L38-1 and L38-2. There are, however, some temporal differences between the two data sets.

### Dissolved Oxygen and Specific Conductivity

Dissolved oxygen levels were consistently lower during backpumping sampling. MARSH-1, whose mean dissolved oxygen level before discharge had been 7.0 mg/L, dropped to 3.3 mg/L during the discharge period. All of the other sites also experienced a similar drop. This difference in dissolved oxygen levels may be attributed to seasonality or resuspension of oxygen depleting bottom sediments during discharge activity. However, more likely it is the direct result of low dissolved oxygen seepage water which tends to replace water removed from the supply side during pumping activity.



A decrease in specific conductivity was a consistent trend also noted during discharge for all sites. The grand mean conductance for all stations in the period prior to G-123 construction averaged 1070  $\mu\text{mhos/cm}$ . During discharge that grand mean decreased to 865  $\mu\text{mhos/cm}$ . The decrease was relatively uniform among the eight stations.

#### Turbidity, Color, and Total Suspended Solids

Turbidity levels at all but two sites decreased during discharge activity. The exceptions were NNR2, on the upstream side of G-123, which almost doubled from 2.3 NTU to 4.2 NTU, site L38-1 which exhibited a more moderate increase from 3.1 NTU to 3.4 NTU. However, in general, turbidity levels decreased during pumpage from an eight station grand mean of 3.5 NTU to 2.5 NTU.

Similarly, color levels also decreased at all but two stations - NNR1 and L38-2. The shift in grand means, however, was negligible - from 101 units to 97 units.

Total suspended solids during the period of discharge decreased substantially for all sites except NNR1 which remained unchanged. Grand means, however, dropped from 7.1 mg/L before construction to 3.1 mg/L during pump activity.

Two of the factors which affect water quality during discharge activity are the effects of turbulence caused by pumping and the inflow of local runoff during rainfall which predicated the use of the pump. Both of these factors would expectedly cause an increase in the aforementioned three indices. This, however, was not the case as decreasing levels were more evident.

#### Macronutrients

Total nitrogen concentrations at the eight sampling sites demonstrated consistently lower levels during the period of discharge than before discharge. Grand mean total nitrogen dropped from 2.91 mg/L to 2.13 mg/L

during pump activity. Inorganic nitrogen levels were not as consistent. Half of the sites exhibited decreased concentrations during pumping, but for the other four (those nearest the pump station) levels of inorganic nitrogen increased. This is not unusual since several other studies, in the vicinity of the Everglades Agricultural Area, (Millar 1983; Jones 1982; Federico 1982) have reported increases in inorganic nitrogen (especially nitrates) during pumping activity.

Total phosphorus levels also exhibited a decline during discharge periods from a grand mean of 0.045 mg/L to 0.015 mg/L. Only station MARSH-1 displayed a modest increase in concentration. Ortho phosphorus levels during pumping decreased to detection limits (0.004 mg/L) at all sites.

#### Chloride, Hardness, and Alkalinity

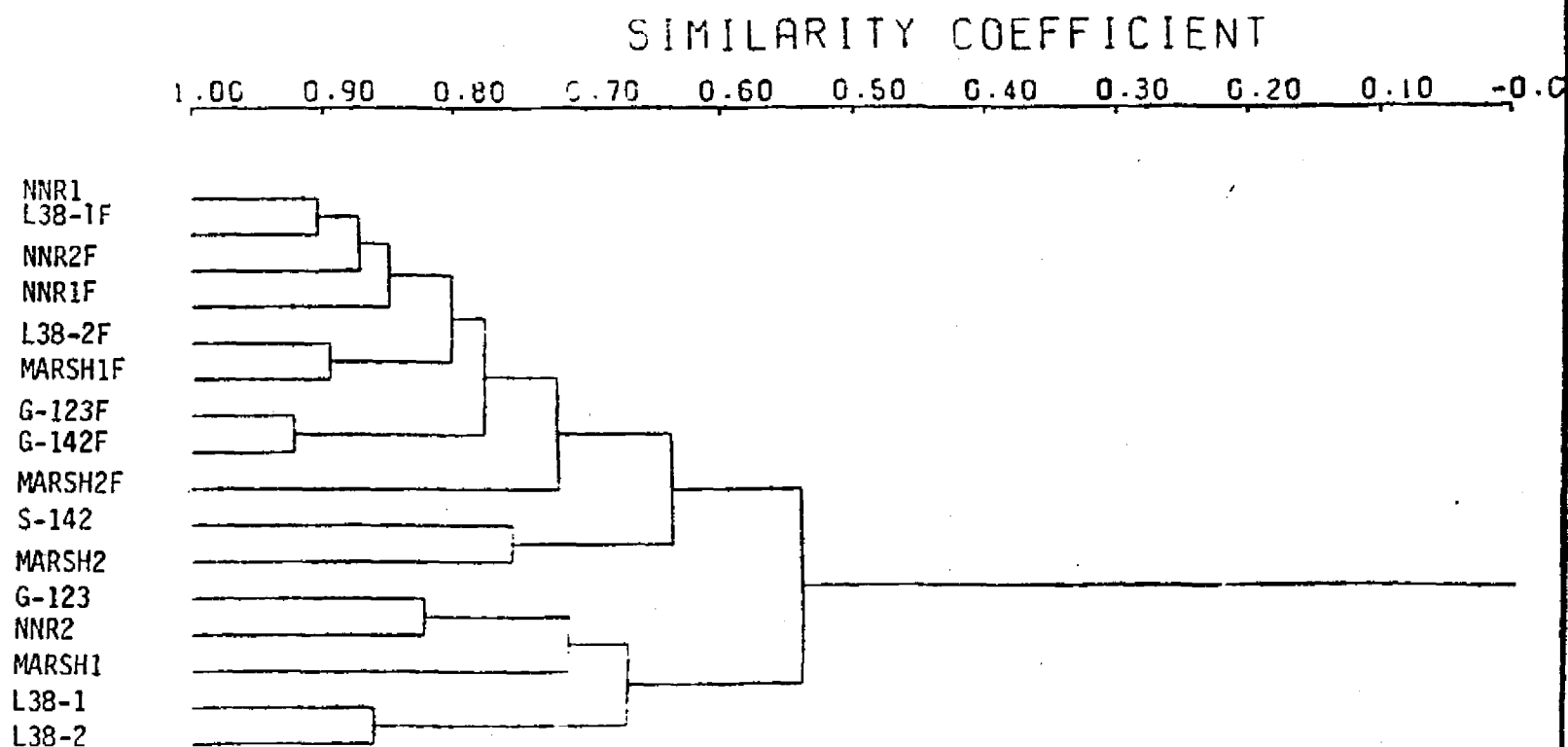
Like many of the other water chemistry indices all three of these parameters displayed consistently lower levels during the period of discharge. Grand means dropped from 150 mg/L to 111 mg/L for chloride, 5.39 meq/L to 4.81 meq/L for alkalinity, and from 311 mg/L to 240 mg/L for hardness.

#### Discharge Conclusions

During the periods of G-123 discharge, the levels of most chemical parameters at the selected study sites decreased indicating a generally improved state in water quality. The exception is dissolved oxygen, whose lower levels recorded during discharge would be considered.

To graphically represent the differences among water quality stations during periods of discharge, as compared to the pre-construction period, a cluster analysis was run for all eight stations and both sets of conditions. The resultant dendrogram is presented as Figure 4. As a group the water quality data (at least for these five parameters) displays a high level of association or similarity for all stations during discharge. The same stations during pump inactivity were much less similar. The exception is site

DENDROGRAM FLOT NUMBER  
 CLUSTER ANALYSES IN TP CL COND TURB  
 USING PINKHAM AND PEARSON COEFFICIENT OF ASSOCIATION.  
 0-0 MATCHES EQUAL ONE  
 GROUP SIZE UNIMPORTANT



'F' denotes site quality during discharge

Figure 4. Cluster Analysis of all Sites Before and During Discharge

NNR1 which displays little discharge related difference, probably due to its relatively long distance from G123.

A simple explanation for the consistent lower values of chemical parameters during the period of discharge (12/82 and 1/83) as compared to the period before G-123 completion (2/82 - 6/82) might have been rainfall dilution; however, that was not the case. Rainfall during the predischage period averaged 4.76 inches per month at S-34. During December 1982 and January 1983, rainfall averaged only 3.70 inches per month. Therefore, it is doubtful that rainfall dilution could be the cause of these parametric decreases.

A second theory is that these lower levels recorded in the marsh area during discharge could be lower because of reduced influence by the S-11 discharges. However, according to District records, the S-11 structures discharged a greater quantity of water during the December/January period (125,937 ac-ft) than during the pre-construction period (105,607 ac-ft). A comparison of the water quality going through the S-11 structures during each time period (Table 4) demonstrated similar values, with the exception of dissolved oxygen and total nitrogen which both displayed 20% lower levels during the G-123 backpumping. This, in combination with the low nutrient and dissolved oxygen levels of G-123 discharge water, acted to lower nutrient and dissolved oxygen levels throughout the study area during G-123 operation. It should be kept in mind that the S-11 discharges quoted above are substantial compared to the total G-123 discharge (15,056 acre-feet) and these discharges may strongly impact the study area.

The third and most plausible explanation for the lower parametric observations during discharge activity would be the increased influence of groundwater and WCA-2B seepage during pumping.

TABLE 4. COMPARISON OF SELECTED S-11 DISCHARGE WATER  
QUALITY DATA BEFORE AND DURING G-123 ACTIVITY

Before G-123 Discharge 1/1/82 - 6/30/82

	<u>D.O.</u> <u>mg/L</u>	<u>Cond.</u> <u>umhos/cm</u>	<u>Color</u> <u>units</u>	<u>TPO<sub>4</sub></u> <u>mg/L</u>	<u>NO<sub>x</sub></u> <u>mg/L</u>	<u>Total N</u> <u>mg/L</u>	<u>Cl</u> <u>mg/L</u>	<u>Hard</u> <u>mg/L</u>
S11A	5.4	1067	120	.017	.073	2.96	165	276
S11B	4.7	962	119	.030	.260	2.99	157	265
S11C	<u>4.0</u>	<u>1045</u>	<u>154</u>	<u>.072</u>	<u>.626</u>	<u>3.55</u>	<u>156</u>	<u>320</u>
Avg.	4.7	1025	131	.040	.320	3.17	159	287

During G-123 Discharge 12/1/82 - 1/30/83

S11A	4.7	1010	104	.039	.272	2.34	142	289
S11B	4.3	1008	112	.051	.318	2.75	157	335
S11C	<u>2.6</u>	<u>1031</u>	<u>129</u>	<u>.052</u>	<u>.339</u>	<u>2.59</u>	<u>130</u>	<u>330</u>
Avg.	3.9	1016	115	.047	.310	2.56	143	318

## DISSOLVED OXYGEN

### Routine Grab Data

In situ dissolved oxygen measurements were taken at each sampling station when water samples were collected for laboratory analysis. A summary of those data is given in Table 5. These discrete daytime values ranged from a low of 0.4 mg/L, measured at NNR1 on January 6, 1983, to a high of 11.4 mg/L, measured at station MARSH-2 on April 12, 1982. This, in itself, is somewhat unusual in that typically dissolved oxygen levels in south Florida tend to be higher during the cooler winter months compared to the summer. However, the range and mean values recorded at each station are typical of dissolved oxygen concentrations encountered in south Florida. The minimum values for all but one sampling site occurred during discharge, specifically during the 1/6/83 sampling trip. The maximum dissolved oxygen values occurred at no particular consistent time during the four month sampling period.

### Diel Data

In addition to the dissolved oxygen measurements made at the time of water sample collection, diel monitoring of dissolved oxygen levels were made at selected stations using a YSI<sup>(R)</sup> D.O. recorder.

<u>Station</u>	<u>Date Range</u>
S-142	March 1 - 5, 1982
L38-1	March 1 - 5, 1982
MARSH-2	March 1 - 5, 1982
NNR2	April 2 - 8, 1982
L38-2	May 10 - 13, 1982
MARSH-2	January 6 - 13, 1983

The data for each date is presented in Figures 5 through 10, respectively.

One of the graphs in particular (NNR2) displays a classic D.O. diel curve - late afternoon peaks and early morning minima. Those graphs for

TABLE 5. MINIMUM AND MAXIMUM  
DISSOLVED OXYGEN VALUES

	<u>Min.</u>	<u>Max.</u>
NNR1	0.4 (1/6/83)	5.9 (4/12/82)
NNR2	1.2 (1/6/83)	5.1 (6/23/82)
S-142	1.2 (1/6/83)	5.4 (3/22/82)
L38-1	2.3 (1/6/83)	9.3 (2/25/82)
L38-2	2.0 (1/6/83)	10.5 (3/1/82)
MARSH-1	2.1 (6/16/82)	7.5 (3/1/82)
MARSH-2	0.9 (1/6/83)	11.4 (4-12)

Value in mg/L  
(Date)

TEMPERATURE DATA

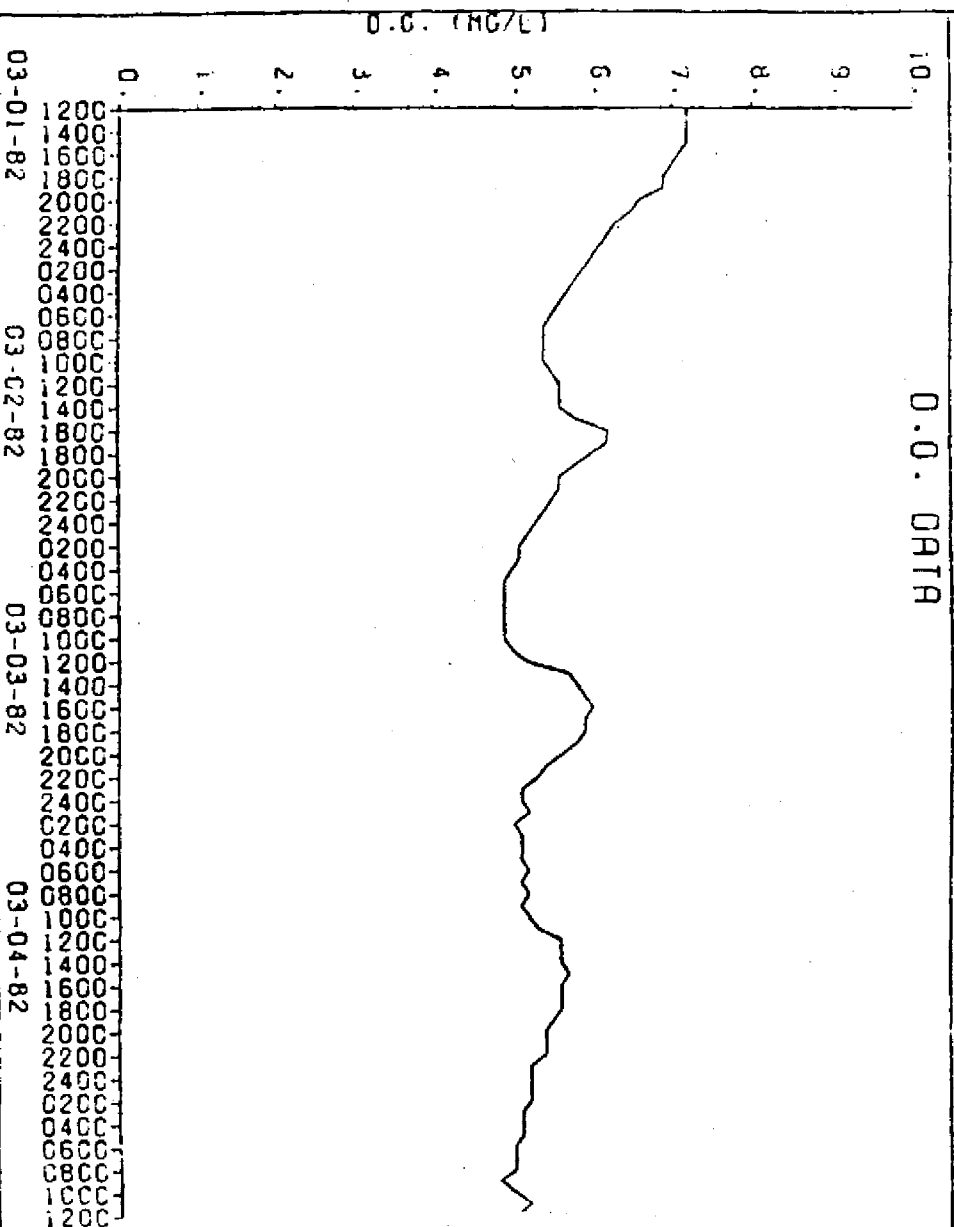
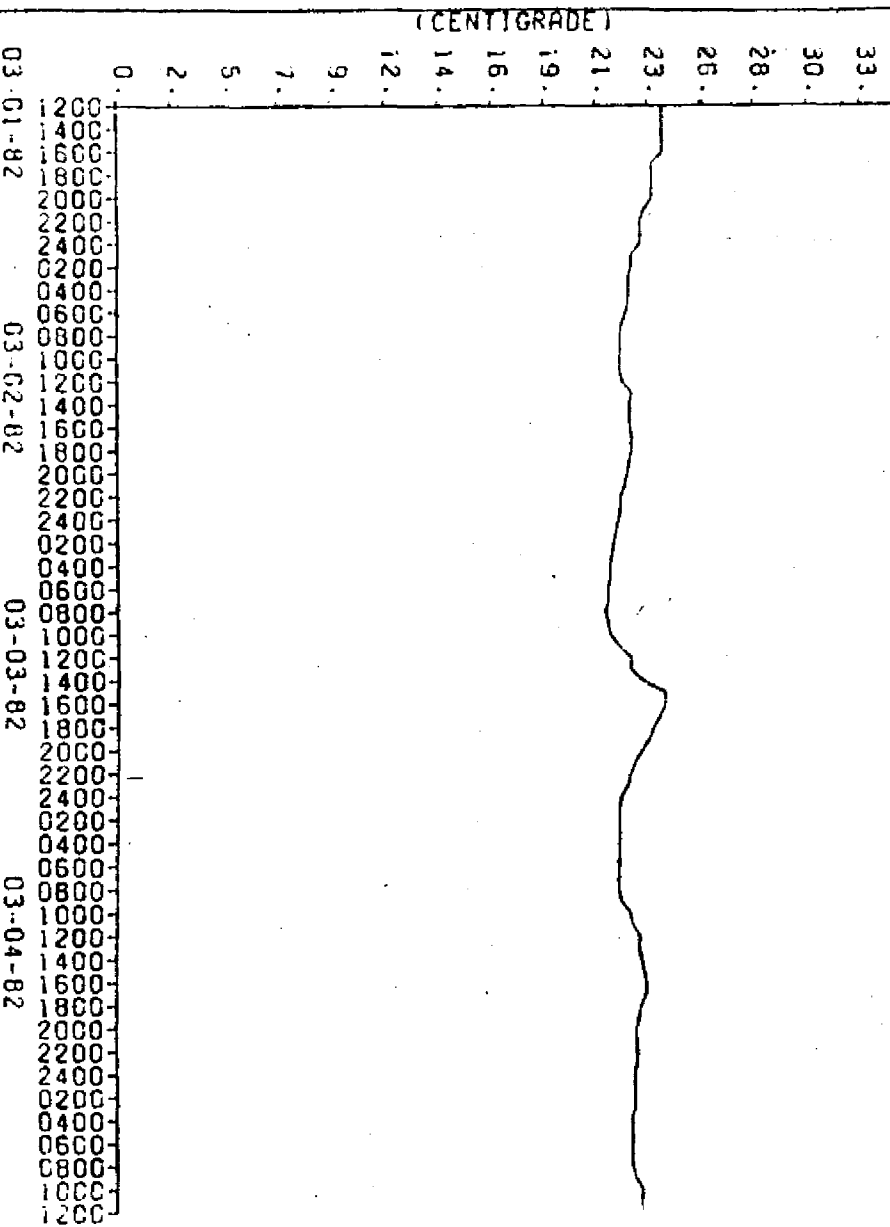
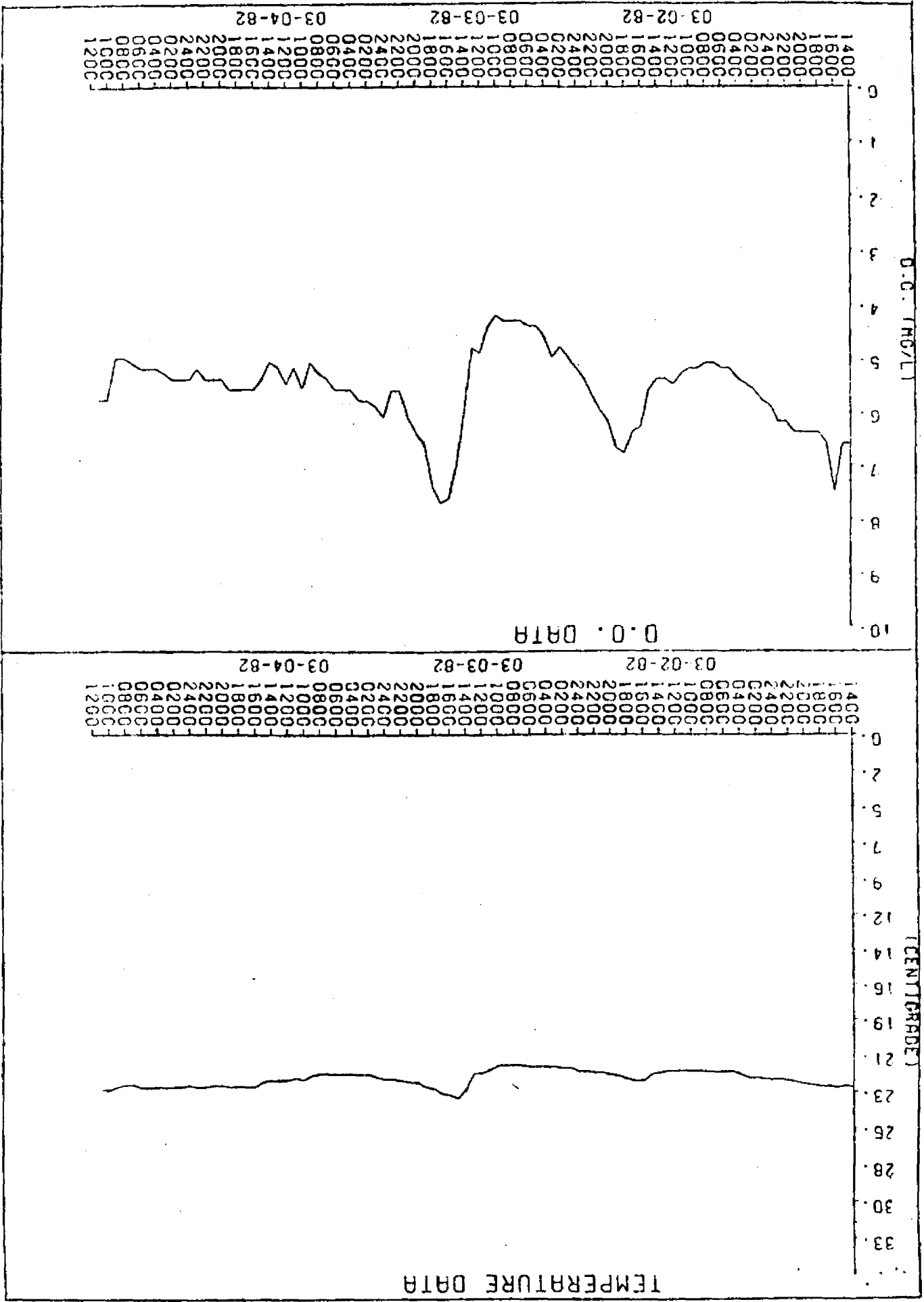


Figure 5. S-142 Dissolved Oxygen Data, March 1-5, 1982



Figure 6. L38-1 Dissolved Oxygen Data, March 1-5, 1982



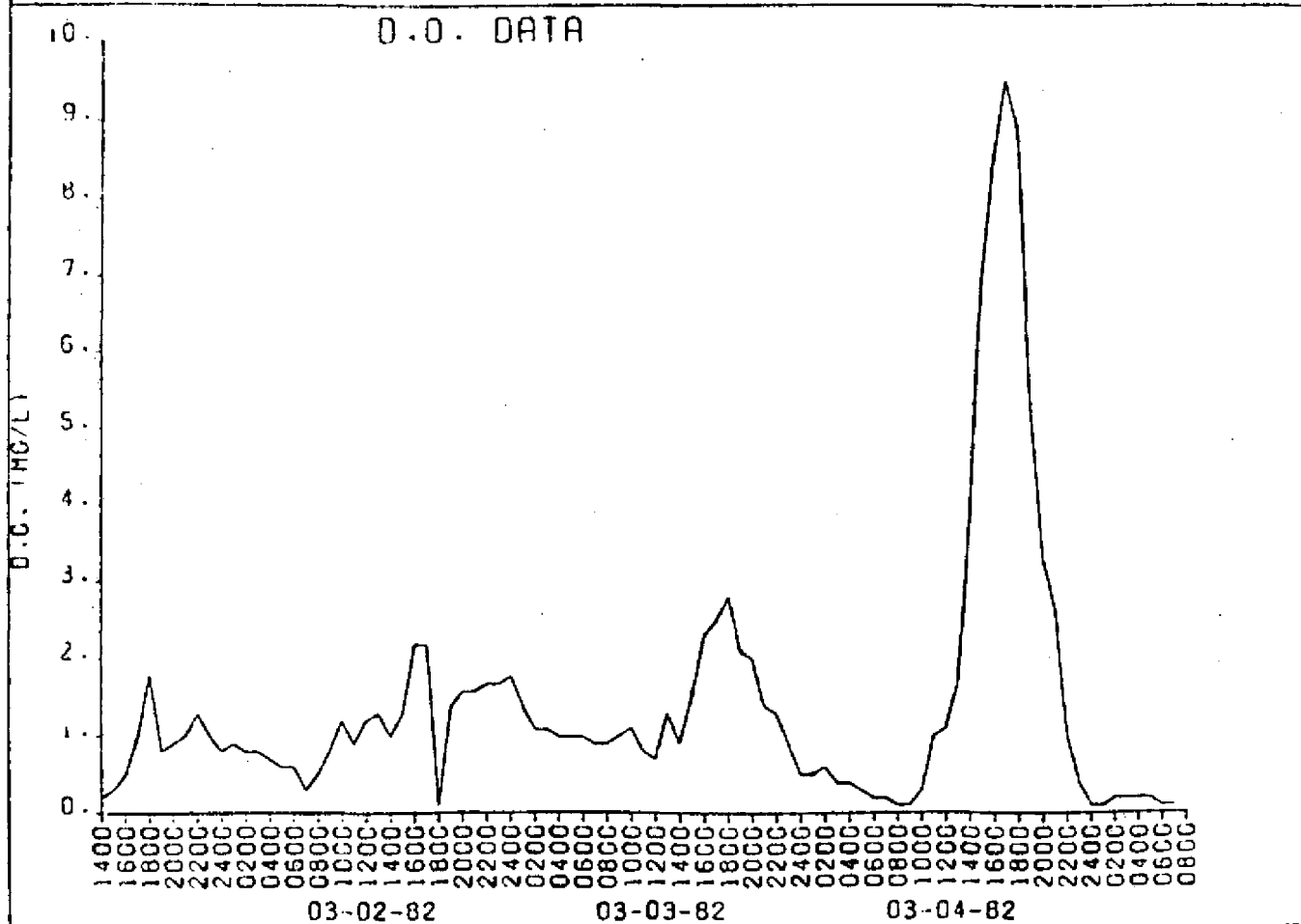
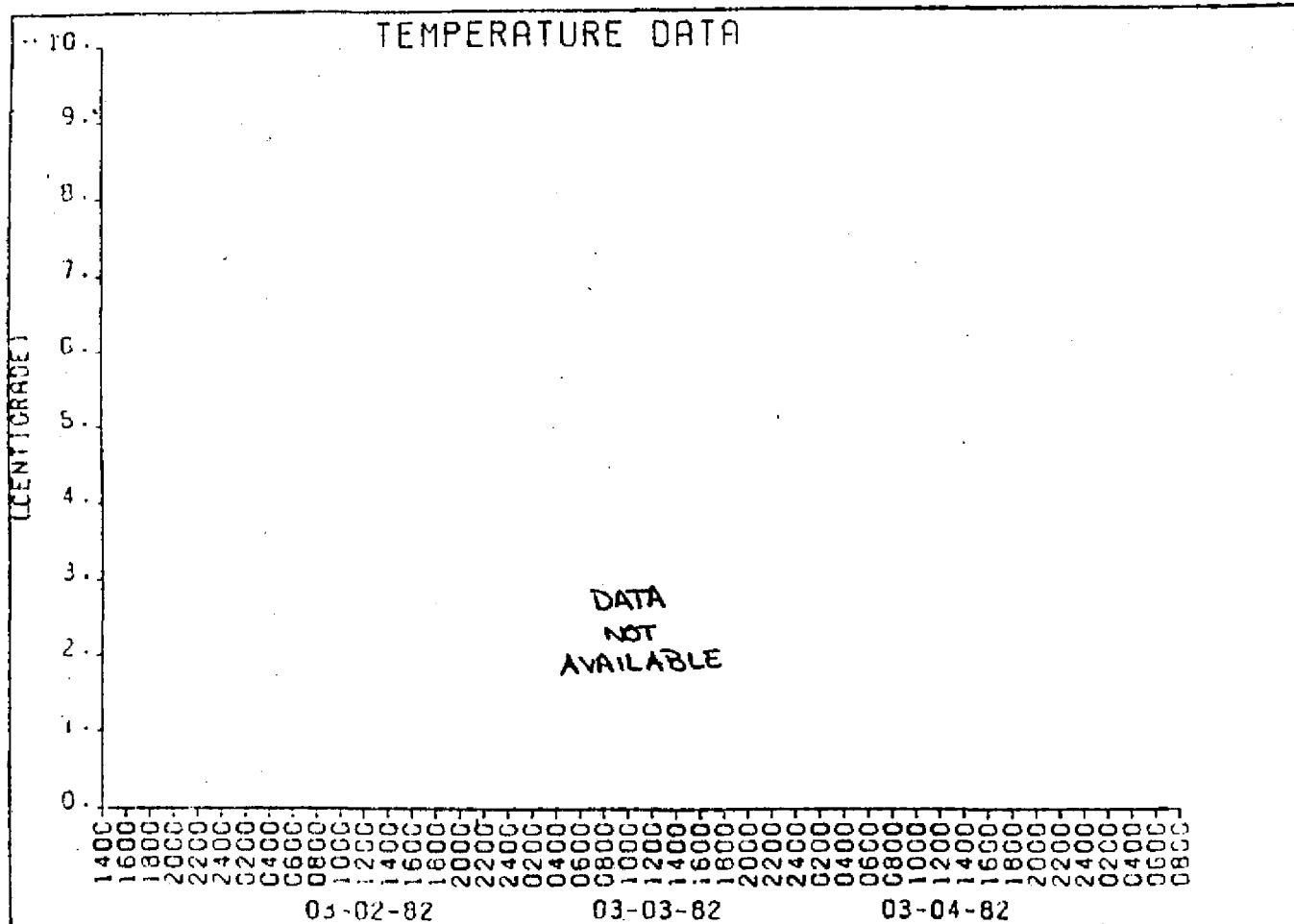


Figure 7. MARSH-1 Dissolved Oxygen Data, March 1-5, 1982

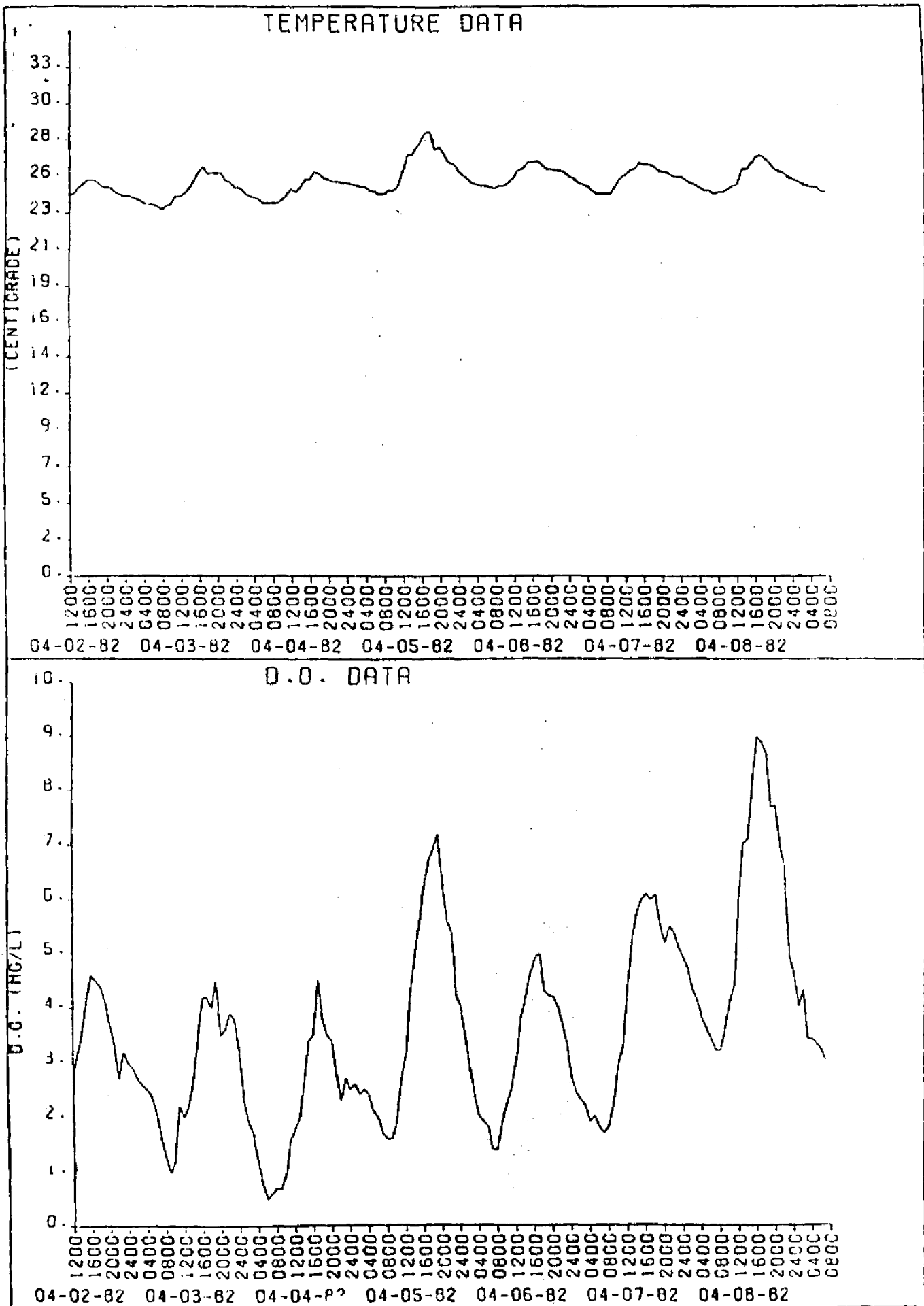


Figure 8. NNR2 Dissolved Oxygen Data, April 2-8, 1982



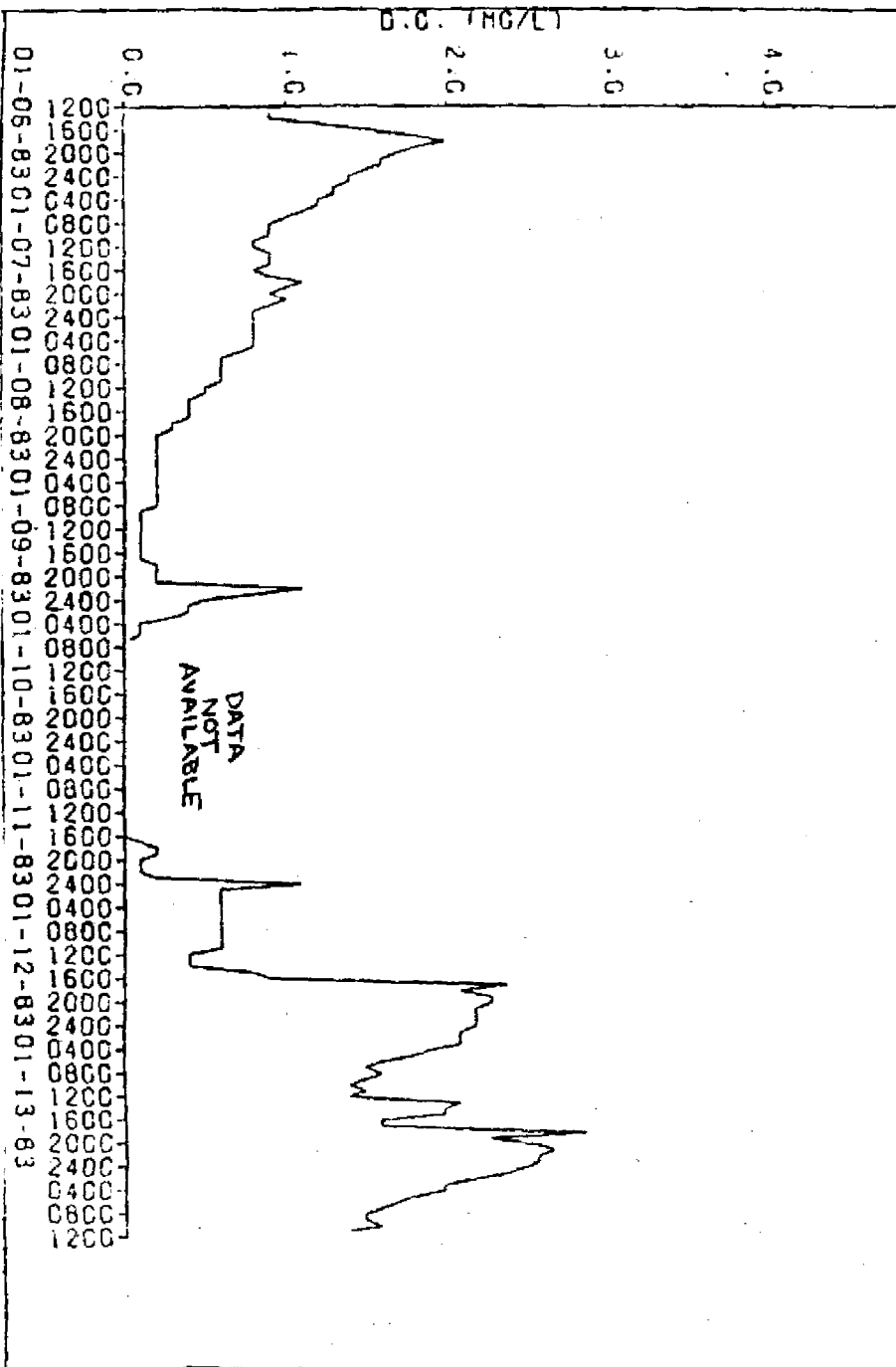


Figure 10. MARSH Dissolved Oxygen Data, January 6-13, 1983





L38-2 and S-142 also displayed this pattern but to a more subtle extent. The dissolved oxygen curve for MARSH-2 (1982) showed a particular irregularity. For the first four days the station displayed low D.O. levels rarely exceeding 2.0 mg/L. On the last day the D.O. increased to a maximum of 9.5 mg/L and dropped to background levels just as suddenly. It is doubtful that this anomaly could have been caused by discharge impact since neither the S-142 nor the MARSH-2 graphs displayed the same event.

A preliminary look at both the diel and routine grab dissolved oxygen data would seemingly indicate that G-123 discharge causes a lowering of oxygen levels within the study area. However, it must be kept in mind that the data collected during discharge may be seasonally biased, and represents only two January sampling trips. The lower dissolved oxygen values recorded during discharge were evident at all stations, even those two sites upstream of the pump station. Therefore, it is equally likely that oxygen levels dropped in the marsh during discharge because the water being pumped is lower in dissolved oxygen or seasonal factors in January 1983, unassociated with a pumping caused by a general decrease in dissolved oxygen levels.

## TRACE ORGANICS AND TRACE METALS

Special water and sediment analyses for trace organics and metals were conducted twice to reflect values before (3/23/82) and during discharge (1/17/83). All analyses were performed by Everglades Laboratories, Inc., West Palm Beach, Florida. Results of the analyses of hydrocarbons, BOD, coliforms, and oil and grease are presented in Table 6. On 3/26/82 additional water samples were collected at all stations except MARSH-1, which was dry, and analyzed by the SFWMD laboratory for the same five trace metals as were measured in the sediments. Zinc analysis was also added by the SFWMD laboratory.

### Water

The trace organic analysis indicated that there is little concern for trace organic pollution in this area. The only hydrocarbon which was detected in the water samples collected during these two dates was Silvex (2,4,5-TP). Silvex, chemically named Trichlorophenoxy propionic acid, is an aquatic herbicide used to control emergent and submergent weeds. Silvex also is used commonly on sugarcane, rice, and rangelands. It is not uncommon for Silvex to be found in south Florida waters. Previous scans have detected this herbicide in both the water conservation areas and the Everglades Agricultural Area. Although there is no Chapter 17-3 State Standards for Silvex in Class III waters, the DER and EPA set an upper level for Class I (potable) waters at 10.0 µg/L, which is far in excess of this recorded value of 0.79 µg/L.

Both the total and fecal coliform levels at these sites were below Chapter 17-3 State Standards for both collection dates. Additionally, oil and grease concentrations were below the detection limit of 1.0 mg/L.

The results of the SFWMD trace metal analysis of the water samples (Table 7) are somewhat confusing in that the higher values for all metals



TABLE 6. RESULTS OF WATER ANALYSES AT SELECTED SITES BEFORE AND DURING DISCHARGE

	NNR2		L38-1		MARSH-2	
	<u>3/23/82</u>	<u>1/7/83</u>	<u>3/23/82</u>	<u>1/7/83</u>	<u>3/23/82</u>	<u>1/7/83</u>
Heptachlor	<0.0002	<0.001	<0.0002	<0.001	<0.0002	<0.001
Aldrin	<0.0003	<0.001	<0.0003	<0.001	<0.0003	<0.001
Endosulfan	<0.0005	<0.001	<0.0005	<0.001	<0.0009	<0.001
Dieldrin	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001
DDT	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mirex	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lindane	<0.0002	<0.004	<0.0002	<0.004	<0.0007	<0.004
Endrin	<0.0003	<0.004	<0.0003	<0.004	<0.0005	<0.004
Methoxychlor	<0.004	<0.03	<0.004	<0.03	<0.001	<0.03
Toxaphene	<0.002	<0.005	<0.002	<0.005	<0.004	<0.005
Chlordane	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Demeton	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1
Guthion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Malathion	<0.03	<0.1	<0.03	<0.1	<0.03	<0.1
Parathion	<0.02	<0.04	<0.02	<0.04	<0.02	<0.04
A1260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
A1016	<0.001	<0.001	<0.001	<0.001	<0.003	<0.001
A1242	<0.001	<0.001	<0.001	<0.001	<0.003	<0.001
A1254	<0.001	<0.001	<0.004	<0.001	<0.003	<0.001
2-4-D	<0.09	<0.1	<0.09	<0.1	<0.09	<0.1
2-4-5-TP(Silvex)	<0.02	<0.02	0.79	<0.02	<0.02	<0.02
Total Coliform*	540	540	17	130	640	350
Fecal Coliform*	<2	<2	<2	33	33	17
BOD (mg/L)	6	5	8	5	10	4
Oil&grease(mg/L)	<1	<1	<1	<1	<1	<1

\* (MPN/100 ml)

All analyses conducted by Everglades Laboratory, West Palm Beach, Florida

All observations in µg/L except where specified.

TABLE 7 TOTAL TRACE METALS - MARCH 26, 1982  
WATER SAMPLES

<u>Stations</u>	<u>As</u>	<u>Cd</u>	<u>Cu</u>	<u>Pb</u>	<u>Hg</u>	<u>Zn</u>
NNR1	8.5	1.6*	3.0	14.5	<0.1	2.0
NNR2	9.6	<0.03	2.2	3.4	<0.1	20.0
S-142	8.5	1.5*	0.6	14.9	<0.1	20.0
L38-1	7.1	2.2*	2.0	11.2	<0.1	40.0*
L38-2	12.6	1.7*	21.1	10.3	<0.1	40.0*
MARSH-1	-	-	Dry Station	-	-	-
MARSH-2	13.1	1.4*	21.8	18.9	<0.1	60.0*

All values in µg/L

\*Denotes values in excess of State Standards (17-3 Class III Waters)

except cadmium and mercury were measured in the samples from either the marsh or the L-38 canal. This trend was particularly evident for the metals arsenic, copper, lead, and zinc. As was the case with the sediment samples (following section) it was expected that the trace metals concentrations might be higher in the NNR Canal than in the marsh due to its closer proximity to highway runoff. Of course, the high values in the L-38 canal could be due in part to the impacts of EAA agricultural runoff from the S-7 drainage basin via the S-11 structures. The cadmium values were about the same at all stations, except one which was much lower than the rest, and all mercury values were below the detection limit of 0.1 µg/L. All of the cadmium values except for the very low one at station NNR2 were slightly above the state standard of 1.2 µg/L for Class III waters. The two L-38 station values and the one marsh station value for zinc was above the standard of 30 µg/L. Due to the relatively large uncertainty associated with any trace metal analysis, no major significance should be placed on any of these individual data points. Additional sampling will be required to determine if these levels and trends are consistent and, therefore, meaningful.

#### Sediments

Concurrent with water analysis, sediment herbicide/pesticide scans demonstrated no parametric values above detection limits either before or during discharge events (Table 8).

Sediment analyses for both collection dates also included the result of a scan of five heavy metals: arsenic, cadmium, copper, lead, and mercury. These results are included in Table 9.

For the samples collected on 3/23/82 (before discharge), levels of arsenic, copper, and lead were highest at station NNR2, the site nearest the intersection of state highways 27 and I-75. Wanielista, et al. (1978)

TABLE 8. RESULTS OF SEDIMENT ANALYSES AT SELECTED SITES  
BEFORE AND DURING DISCHARGE

	NNR2		L38-1		MARSH-2	
	<u>3/23/82</u>	<u>1/7/83</u>	<u>3/23/82</u>	<u>1/7/83</u>	<u>3/23/82</u>	<u>1/7/83</u>
Heptachlor	<0.04	<0.04	<0.02	<0.02	<0.1	<0.1
Aldrin	<0.1	<0.05	<0.03	<0.03	<0.1	<0.2
Endrosulfan	<0.1	<0.1	<0.1	<0.1	<0.3	<0.4
Dieldrin	<0.01	<0.1	<0.01	<0.1	<0.3	<0.3
DDT	<0.3	<1.6	<0.2	<0.2	<0.5	<0.9
Mirex	<0.3	<0.2	<0.1	<0.1	<0.4	<0.7
Lindane	<0.1	<0.03	<0.02	<0.02	<0.1	<0.09
Endrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4
Methoxychlor	<0.5	<0.3	<0.2	<0.2	<0.6	<1.1
Toxaphene	<5.0	<6.8	<3.3	<3.7	<9.1	<21.6
Chlordane	<1.0	<0.7	<0.6	<0.4	<1.6	<2.2
Demeton	<2.0	<1.4	<1.0	<0.7	<6.0	<3.7
Guthion	<9.0	<4.3	<6.0	<2.0	<15.0	<11.5
Malathion	<2.0	<2.9	<2.0	<2.8	<4.0	<7.8
Parathion	<2.0	<3.2	<1.0	<1.5	<3.0	<8.4
A1260	<0.5	<0.5	<0.4	<0.3	<0.8	<1.6
A1016	<5.0	<0.7	<4.0	<0.4	<7.0	<2.3
A1242	<3.5	<0.7	<2.0	<0.4	<5.5	<2.4
A1254	<1.6	<0.9	<0.9	<0.5	<3.7	<2.9
2-4-D	<6.0	-	<4.0	-	<7.0	-
2-4-5-TP (Silvex)	<1.0	-	<1.0	-	<1.0	-

All analyses conducted by Everglades Laboratory, West Palm Beach, Florida  
All observations in µg/L

TABLE 9. COMPARISON OF TRACE METAL DATA IN THE SEDIMENTS OF SELECTED SITES (3/23/82) BEFORE AND DURING (1/7/83) DISCHARGE

<u>(mg/Kg)</u>	<u>NNR2</u>		<u>L38-1</u>		<u>MARSH-2</u>	
	<u>3/23/82</u>	<u>1/7/83</u>	<u>3/23/83</u>	<u>1/7/83</u>	<u>3/23/82</u>	<u>1/7/83</u>
Arsenic	44.6	3.3	28.6	3.7	16.9	1.9
Cadmium	0.44	0.11	0.59	0.07	0.08	0.01
Copper	53.3	10.5	16.2	14.5	14.8	0.93
Lead	17.3	22.3	8.5	12.2	4.1	6.7
Mercury	0.004	<0.01	0.001	<0.01	0.008	<0.01

All analyses conducted by Everglades Laboratory, West Palm Beach, Florida

conducted a study for the Florida Department of Transportation (DOT) which indicated that most of the metals from stormwater runoff were being retained in the soils adjacent to highway bridges. Yousef et al. (1983) agreed with Wanielista and added that lead was apparently the leading indicator of substrate contamination by highway runoff.

This observation would also seem to be supported by the 1/7/83 data which also indicated that lead levels were highest in those sediments at the site nearest to this large traffic intersection (NNR2). In the second analysis cadmium and lead were also greatest at NNR2 and arsenic levels were marginally greater at L38-I.

There will be no attempt to strictly compare levels between sampling dates due to the extreme heterogeneity of sediment analysis. However, it is interesting to note that in March 1983 a similar analysis of metals, conducted by the District in freshwater sediments in the vicinity of the St. Lucie Canal (C-44), yielded much higher discrete levels. Specifically, the average of four stations were: arsenic (41.0 mg/kg), cadmium (0.86 mg/kg), copper (104.9 mg/kg), mercury (2.44 mg/kg) and lead (40.1 mg/kg). These values are considerably higher than any of these study observations either before or during discharge.

## FINDINGS

1. Background water chemistry data (nutrients, metals, trace organics, etc.) within the study area indicate no significant water quality problems, with the exception of generally low dissolved oxygen levels among the sampling sites prior to pump (G-123) activity.
2. During G-123 discharge the levels of almost all measured water indices decreased at both upstream and receiving sites. This would suggest a general improvement of water quality, with the important exception of dissolved oxygen levels whose decrease would be termed adverse.
3. During the pre-backpumping period the four sampling sites within WCA-3A seem to reflect S-11 discharge. During discharge the water quality at these sites combines with G-123 discharge to generally lower (improved) levels.
4. The impact of G-123 discharge within the study will be better realized when a dye tracer study is completed to establish mixing zones and the speed of mixing.
5. The results of this data report are based on an extremely limited data base. Discharge data is averaged from only two sampling trips and may demonstrate strong seasonal bias. Subsequent sample collection during discharge events will greatly enhance the analysis of the impact of NNR backpumping.

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**APPENDIX A**

**ANALYTICAL METHODOLOGIES**

8/30/83

SOUTH FLORIDA WATER MANAGEMENT DISTRICT  
Water Chemistry Laboratory

Analytical Methods

**AutoAnalyzer II Method**

<u>Determination</u>	<u>Method</u>	<u>Range</u>	<u>Sensitivity</u>	<u>Detection Limits</u>
Alkalinity	Colorimetric Automated Methyl Orange, Technicon AA II Method #111-71W, modified EPA Method #310.2	0-5.0 meq/L	0.1 meq/L	0.1 meq/L
Ammonia	Colorimetric Automated Phenate, Technicon AA II method #154-71W, modified EPA Method #350.1	0.2-0 mg/L	0.01 mg/L	0.01 mg/L
Chloride	Colorimetric Automated Ferricyanide, Technicon AA II Method #99-70W, modified EPA Method #325.2	0-200.0 mg/L	2.0 mg/L	4.0 mg/L
45 Nitrite	Colorimetric Automated Diazotization with Sulfanilamide and coupling with N-(1 naphthyl) ethylenediamine Dihydrochloride, Technicon colorimetric, automated AA II Method #120-70W, modified EPA Method #353.2	0-0.200 mg/L	0.002 mg/L	0.004 mg/L
Nitrate	Same as nitrite with Cadmium Reduction Column. Technicon AA II Method #100-70W, modified EPA Method #353.2	0-0.200 mg/L	0.002 mg/L	0.004 mg/L
Total Kjeldahl Nitrogen	Colorimetric, Semi-automated Block Digestor, Technicon AA II Method #376-75W, 334-74A, modified EPA Method #351.2	0-0.10 mg/L	0.001 mg/L	0.002 mg/L
Ortho Phosphate	Colorimetric, Automated, Phosphomolybdenum Blue Complex with Ascorbic Acid Reduction, Technicon AA II Method #155-71W, modified EPA Method #365.1	0-2.0 mg/L	0.001 mg/L	0.002 mg/L
Total Phosphate	Colorimetric, Semi-automated Persulfate Digestion followed by same method as Ortho Phosphate Technicon AA II Method #155-71W, modified EPA Method #365.1.	0-2.0 mg/L	0.001 mg/L	0.002 mg/L

## AutoAnalyzer II Method (Cont.)

### Physical Parameters

<u>Determination</u>	<u>Method</u>	<u>Range</u>	<u>Detection Range</u>
Suspended Solids	Gravimetric Standard Methods Procedure #208D, 14th Ed., pp 94, 1975, EPA Methods #160.1 to 160.4	20-20,000 mg/L	1.0 mg/L or 5% whichever is greater
Turbidity	Nephelometric, Standard Methods #214A, 14th Ed., pp 132, 1975, EPA Method #180.1	0-1,000 N.T.U.	2% of scale used
Color	Colorimetric, modified Standard Method #204A, 14th Ed., pp 64, 1975 (modified as per N.C.A.S.I. Technical Bulletin #253) modified EPA Method #110.2	0-500 mg/L as platinum in platinum-cobalt solution	1.0 mg/L

### Metals - Major Cation

#### Atomic Absorption

<u>Determination</u>	<u>Method</u>	<u>Range</u>	<u>Detection Range</u>
Sodium	Atomic Absorption Direct Aspiration with Dual Capillary System, EPA Method #273.1	0-150 mg/L	As calculated from absorbance
Potassium	Atomic Absorption Direct Aspiration with Dual Capillary System, EPA Method #258.1	0-10 mg/L	As calculated from absorbance
Calcium	Atomic Absorption Direct Aspiration with Dual Capillary System, Samples are treated with $\text{La}_2\text{O}_3/\text{HCl}$ , EPA Method #215.1	0-150 mg/L	As calculated from absorbance
Magnesium	Atomic Absorption Direct Aspiration with Dual Capillary System. Same treatment as calcium, EPA Method #242.1	0-40 mg/L	As calculated from absorbance

## Atomic Absorption (Continued)

### Trace Metals

<u>Determination</u>	<u>Method</u>	<u>Range</u>
Zinc	Atomic Absorption, Direct Aspiration, EPA Method #289.1	0-1000 microgram/L
Lead	Atomic Absorption, Furnace Technique, EPA Method #239.2	0-20 microgram/L
Cadmium	Atomic Absorption, Furnace Technique, EPA Method #213.2	0-2 microgram/L
Copper	Atomic Absorption, Furnace Technique, EPA Method #220.2	0-20 microgram/L
Arsenic	Atomic Absorption, Furnace Technique, EPA Method #206.2	0-10 microgram/L
Mercury	Atomic Absorption, Manual Cold Vapor Technique, Modified EPA Method #245.1	0-4 microgram/L