Technical Memorandum

The Response of Vegetation and Benthic Macroinvertebrates to Constructed Littoral Habitat in Canal 51

by

Ken Rutchey

January 1992

DRE 306

Environmental Sciences Division
Research and Evaluation Department
South Florida Water Management District
West Palm Beach, Florida

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXHIBITS

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INTRODUCTION:

This study evaluates the effectiveness of constructed shoreline features to develop productive littoral habitat along a water conveyance canal in an urban area. Natural revegetation and benthic community production of a constructed open and bermed shelf were monitored at three-month intervals to yield eight data collections between September, 1986, and June, 1988. Herbicidal weed control in the project area was discontinued during the study period so that natural colonization could occur.

The littoral zone is the area of water that extends from the shoreline to the limit of occupancy by rooted plants. The development of a littoral zone is influenced by water depth and stability, light transmission, nutrient supply, substrate texture, and water movement (particularly wave action). Once established, the littoral zone typically has a high species diversity and abundance because of the extensive plant coverage, substrate for travel and attachment, food abundance, and dissolved substances.

The littoral zone contains three basic plant assemblages: emergent, floating and submergent species. Emergent plants typical of a littoral habitat in South Florida could include spike rush (*Eleocharis* spp.), *Panicum* spp., bulrush (*Scirpus* spp.), cattail (*Typha* spp.), arrowhead (*Sagittaria* spp.), and arrow arum (*Peltandra* spp.). The floating-leaved plant community often includes white water lily (*Nymphaea* spp.), duckweed (*Lemma* spp.), water fern (*Salvinia* spp.), water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*). These free floating hydrophytes and rooted plants with floating leaves influence energy relationships and community composition in various ways. Extensive coverage by plants in both groups may shield the underlying water from sunlight, thereby inhibiting submerged plant and algal photosynthesis. In warm regions like South Florida, the water underneath such mats frequently has been found to be nearly oxygen depleted (Reid and Wood, 1976).

The third group, submerged vegetation, could include coontail (Ceratophyllum demerson), hydrilla (Hydrilla verticillata), water naiads (Najas spp.), and bladderworts (Utricularia spp.). Stoneworts (Chara spp.) may also be prominent in the submerged vegetation. While most littoral zone plants use the sediment for attachment and nutrients (Carignan and Kalff, 1980; Bristow and Whitcombe, 1971), stoneworts may be considered as wholly aquatic. Stoneworts derive gases and nutrients for photosynthesis and respiration from the water and return nutrients to the water through decomposition.

This study was conducted in response to a condition for a permit (Permit Number 500877569) issued to the South Florida Water Management District on July 15, 1985, by the Department of Environmental Regulation (DER) for maintenance dredging of Canal 51 from Summit Blvd. to Forest Hill Blvd in West Palm Beach, Florida. As stated in specific condition Number 2 of that permit:

> "The permittee shall create a littoral shelf along the eastern shoreline of the canal in the project area. The permittee shall submit a detailed plan of the littoral area within 90 days of the issuance of this permit. The plan (see Exhibit 1 for background information) shall include detailed plan and cross sectional drawings of the area, revegetation criteria including species and percent of guaranteed survival, and monitoring details. The department shall review the plan and notify the permittee regarding the adequacy of the plan within 30 days of receipt by the department".

The Department of Environmental Regulation was concerned that deepening of the Canal 51 may create environments that limit faunal community production.

METHODS and MATERIALS

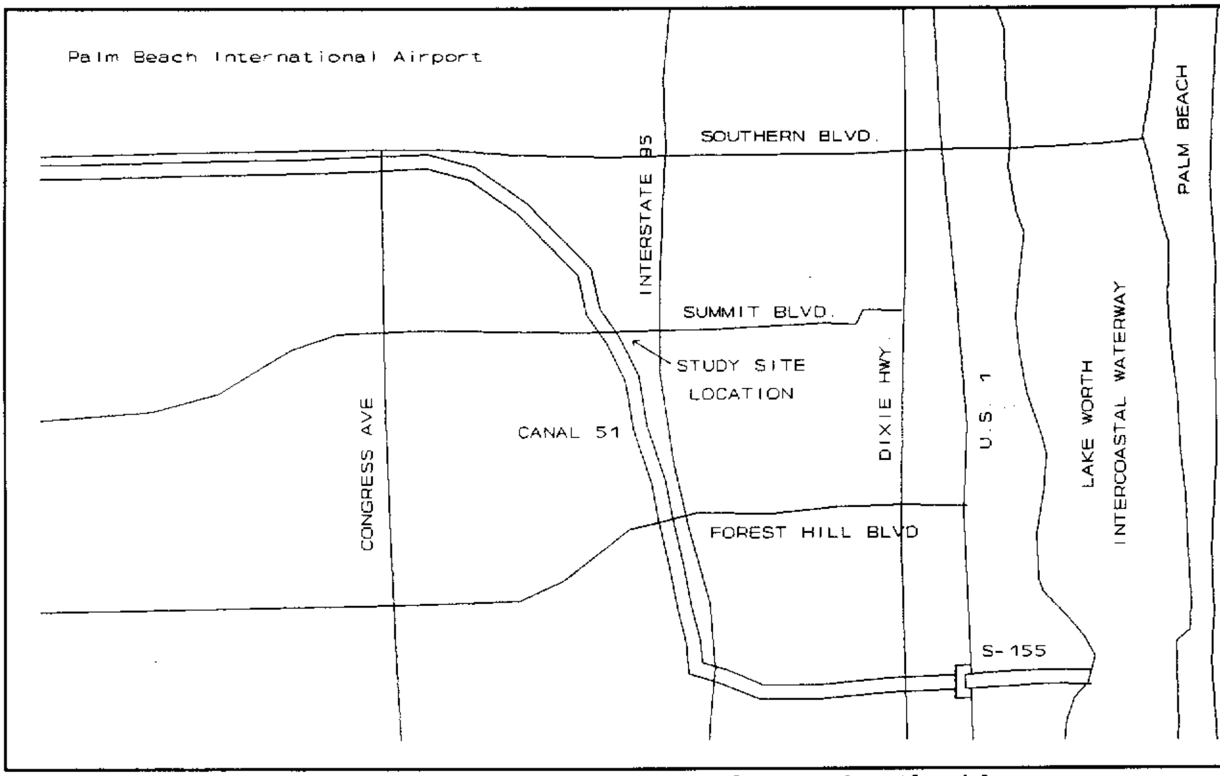


Figure 1. The study site location in West Palm Beach, Florida.

A 170 meter shelf, comprised of an open and bermed region, was constructed just south of Summit Blvd. on the east side of Canal 51 (Figure 1). The open and bermed shallow shelf was constructed to compare littoral habitat development in areas exposed to or protected from wave action and water movement. The littoral shelf was constructed by cutting away the canal bank and leaving a substrate consisting primarily of bare sand. The open shelf study area was approximately 90 m long and 9 to 13.5 m wide, with an average ground elevation and water depth of 2.14 m (7.03 ft.) and 0.33 m (1.08 ft.) National Geodetic Vertical Datum (NGVD), respectively. The bermed shelf study area was approximately 63 m long and 7 to 8.5 m wide with an average ground elevation and water depth of 2.16 m (7.09 ft.) and 0.31 m (1.02 ft.) NGVD, respectively.

Mean water depths and substrate elevations were measured in the open and bermed shelves for each of the collection dates (Figures 3a & 3b). Mean water depth was determined by averaging all water depths measured within each 1.0 m^2

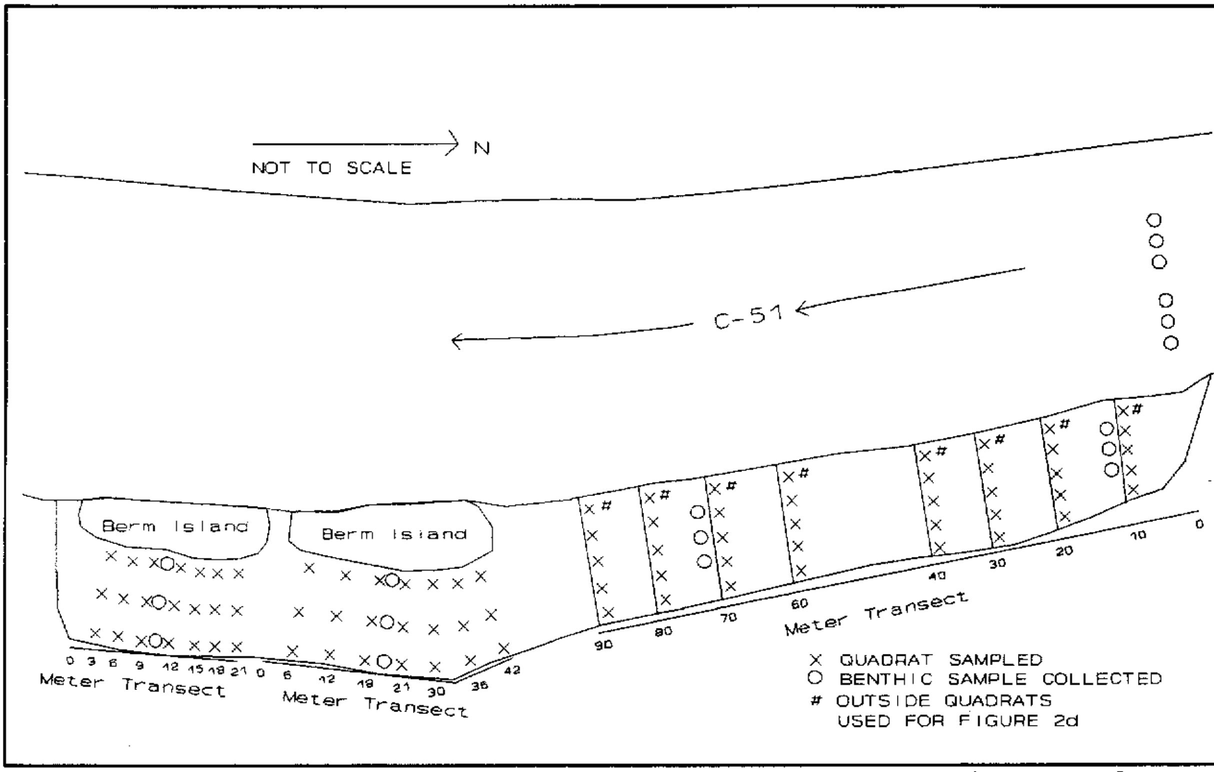


Figure 2. The study site showing bermed (left) and open (right) shelves on Canal 51.

sample quadrat (Figure 2). Ground elevations on the open shelf were inconsistent, suggesting that the soils were unstable. Possible erosion of the shelf bank due to Canal 51 flow (Figure 3c) was examined by measuring ground elevations of peripheral quadrats in the open shelf and plotting these lines for different collection dates (Figure 2 & 3d). Ground elevations were based on stage readings at Structure 155, located 6.4 km (4.0 miles) downstream of the study site.

A grid was established in each of the open and bermed shelves (Figure 2). In

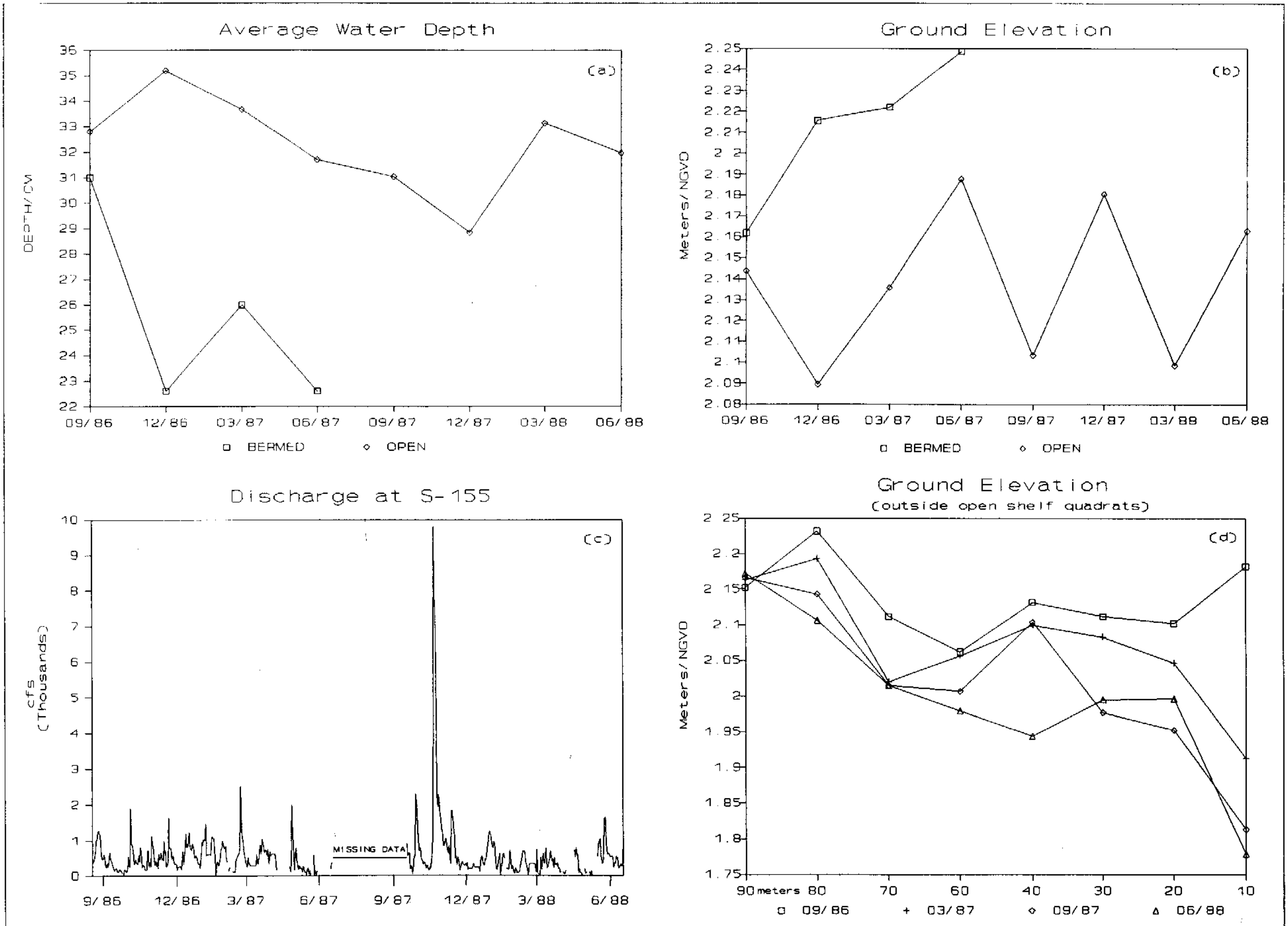


FIGURE 3. Parameters related to the hydrology of the shelf study area.

the open shelf, a 90 m baseline transect was established parallel to the shore and was permanently marked at each end. Transect lines were then positioned perpendicular to the baseline at 10, 20, 30, 40, 60, 70, 80, and 90-m intervals extending outward towards the canal center. Seven equidistant points were then located on each transect. Five 1.0 m^2 quadrats offset 2 m to the north of points two through six were sampled for each line. Thus, a total of 40 quadrats were sampled in the open shelf.

Similar transect lines were established in the bermed shelf. Two separate baseline transects were established 21 and 42 m in length paralleling the shoreline and were permanently marked (Figure 2). Three 1.0 m^2 quadrats were then sampled at 3 and 6 m intervals along the 21 and 42 m tapes, respectively. Thus, a total of 42 quadrats were sampled in the bermed shelf.

Samples from all quadrats in the open and bermed shelves were analyzed for plant species presence (frequency) and species percent coverage (Daubenmire, 1959). Species percent coverage within the quadrats was determined by using seven classifications: (T) <1%, (1) 1-5%, (2) 5-25%, (3) 25-50%, (4) 50-75%, (5) 75-95%, (6) 95-100%. Photographs were taken to document any changes that occurred over time.

Frequency estimates for all plant species recorded in both the open and bermed shelves were determined by taking the total number of quadrats in which a species was found, dividing by the total number of quadrats sampled, and multiplying by 100. Estimates of mean percent coverage were determined by summing the midpoints (T=0.5, 1=3.0, 2=15.5, 3=38, 4=63, 5=85.5, 6=98) for the coded ranges for each species and dividing by the total number of quadrats examined.

For each sampling date, a total of six benthic grab samples were collected from each of the open, bermed, and canal bottom sites to assess the macroinvertebrate populations inhabiting these substrates. Benthic sampling was performed using a Petite Ponar sampler (232 cm^2 sample area). Samples were filtered through a U.S. Standard mesh No. 30 sieve, preserved in the field with 95% ethanol, stained using rose bengal (200 mg/L), and stored in glass jars. Organisms were then sorted and enumerated into taxonomic categories depicted in Table 1. Means and standard errors were calculated for each of the taxonomic categories collected for the open, bermed, and canal sites (Appendices 3 - 6).

TABLE 1. BENTHIC MACROINVERTEBRATES COLLECTED IN THIS STUDY.

CLASS	ORDER	FAMILY	GENUS	SPECIES
Oligochaeta				
Hirudinea				
Crustacea	Cladocera			
Crustacea	Copepoda			
Crustacea	Ostracoda			
Crustacea	Mysidacea	Mysidae	Taphromysis	louisianae
Crustacea	Isopoda			
Crustacea	Amphipoda	Gammaridae	Gammarus	spp.
Crustacea	Amphipoda	Talitridae	Hyalella	azteca
Crustacea	Decapoda	Palaemonidae	Palaemonetes	paludosus
Arachnoida	Hydracarina			
Insecta	Collembola			
Insecta	Ephemeroptera	Baetidae	Callibaetis	spp.
Insecta	Ephemeroptera	Caenidae	Caenis	spp.
Insecta	Odonata			
Insecta	Hemiptera	Unidentified		
Insecta	Hemiptera	Corixidae		
Insecta	Trichoptera	Hydroptilidae		
Insecta	Coleoptera			
Insecta	Diptera	Culicidae		
Insecta	Diptera	Chironimidae		
Insecta	Diptera	Ceratopogonidae		
Gastropoda	Unidentified			
Gastropoda	Mesogastropoda	Ancylidae		
Gastropoda	Mesogastropoda	Thiaridae	Melanoides	turricula
Gastropoda	Mesogastropoda	Viviparidae	Viviparus	georgianus
Pelecypoda	Unionoida	Sphaeriidae		
Pelecypoda	Unionoida	Unionidae		
Pelecypoda	Unionoida	Corbiculidae	Corbicula	manilensis

Phyllum - Nematoda

To test for differences among sites, data were transformed (Log_{10} (Y + 1)) and analyzed with Biometry Statistical Programs (1985). Data were transformed to normalize the frequency distribution of the counts, to eliminate the dependence of the variance on the mean, and to ensure that the components of the variance are additive. A one was added to each count to avoid having a zero density. When variances associated with the means did not differ significantly (tested by the F-statistic ($P<0.05$) for 2 samples and Scheffe-Box test for 3 samples), one-way analysis of variance and/with the Welsch Step-Up Procedure was used to test for differences among sites. The Student's t-test was used to test for differences among sites when variances associated with the mean values differed significantly.

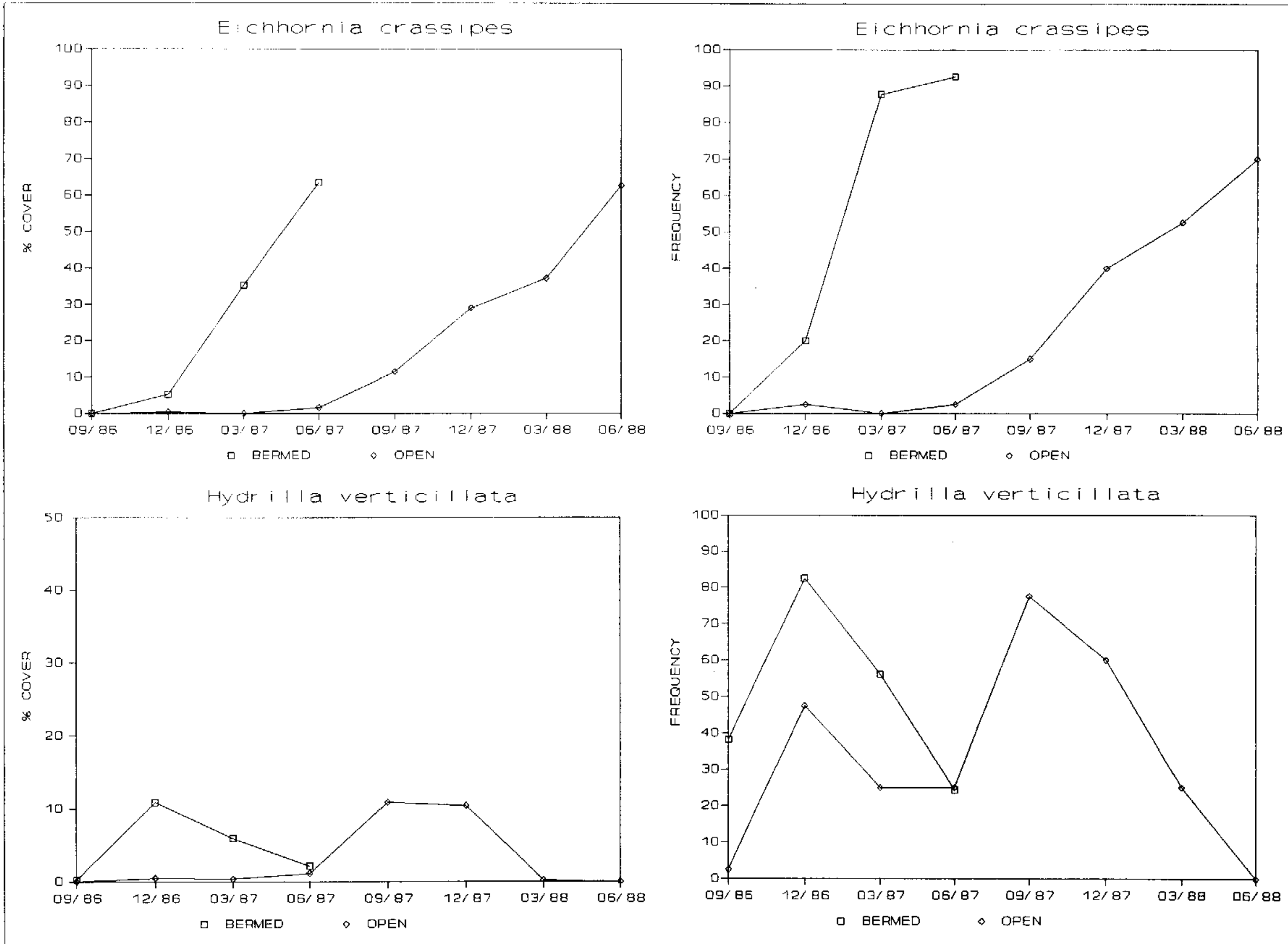
Computation of regression with more than one value of Y per value of X (equal sample sizes) was performed to compare the percentage coverage of _Eichhornia crassipes_ (water hyacinth) (X) against the total number of organisms (Y) collected in the open area. Because the shelf had been recently created, the first three data collections were eliminated from the analysis to allow the area to become stabilized. Organisms and water hyacinth coverage data were transformed (Log_{10} (Y + 1) and Arc sine of square root of Y/100, respectively) and analyzed with Biometry Statistical Programs (1985).

RESULTS and DISCUSSION

Erosion of surrounding terrestrial habitat and consequent sediment deposition on the bermed shelf caused average ground elevations to increase from 2.16 m NGVD (7.09 ft) on September 9, 1986, to 2.25 m NGVD (7.38 ft.) on June 6, 1987 (Figure 3b). Aquatic vegetation rapidly colonized the bermed shelf. The source of this floating vegetation (*Eichhornia crassipes*, *Pistia stratiotes*, and *Salvinia rotundifolia*), along with debris (plastics, cans, wood, and styrofoam), was the canal. *Eichhornia crassipes* quickly became rooted on the shallow shelf and contributed much to the entrapment of this debris. It was concluded that the construction of bermed shelves was not a desirable method for creating littoral shelves within this study area due to the erosion, debris entrapment and accumulation of floating vegetation. Therefore, data collection for the bermed shelf area was discontinued after June, 1987.

The open shelf soils were unstable as a result of exposure to the water movement in Canal 51 and wave action from boating traffic. Some of this soil probably eroded into the canal or onto the shelf itself, which could account for some of the inconsistencies in ground elevations illustrated in Figure 3b. The data also suggest that the south end of the open shelf transect was stable, whereas the north end continued to erode and lose sediments as illustrated in Figure 3d. Recreational boats in the area also used the shelf as a takeoff area for water skiing, leaving gullies in the sediments from the boat props.

Colonization and growth of vegetation in the bermed shelf was more rapid than the open shelf (Figure 4a-e). However, similar species and growth patterns were evident after a nine to twelve-month lag period. *Eichhornia crassipes* was the dominant species observed on the open shelf, increasing in coverage from 0 to 63 percent in two years. Other dominant species were associated with *Eichhornia crassipes* (Figures 4a - e and Appendix Tables 1 & 2).



FIGURES 4A-E. Frequency and cover of dominate (coverage > 1%) vegetation species observed in bermed and open shelves.

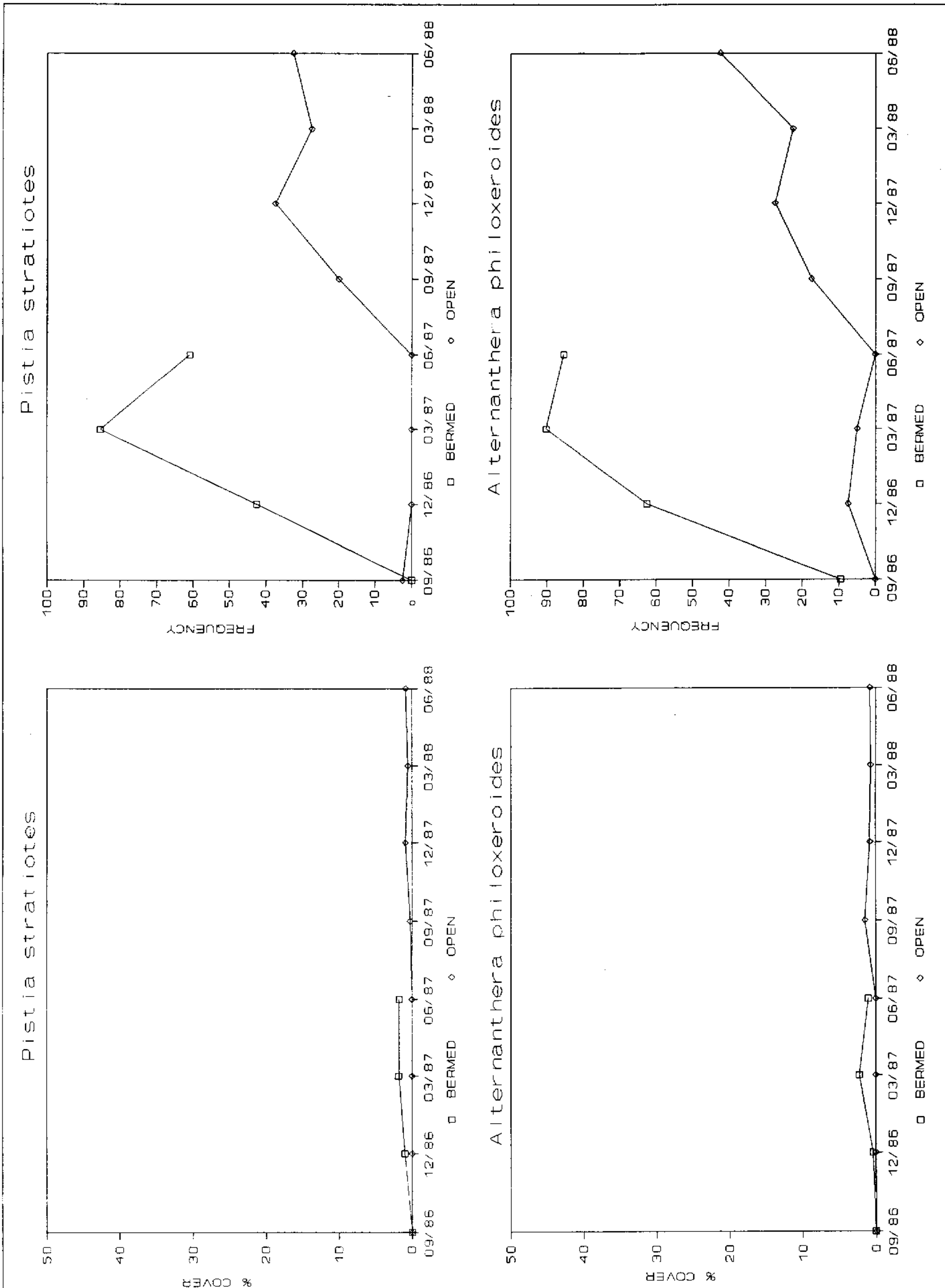

Pistia stratiotes
% COVER
BERMED
OPEN
Pistia stratiotes
FREQUENCY
BERMED
OPEN
Alternanthera philoxeroides
% COVER
BERMED
OPEN
Alternanthera philoxeroides
FREQUENCY
BERMED
OPEN
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88

FIGURE 4B.

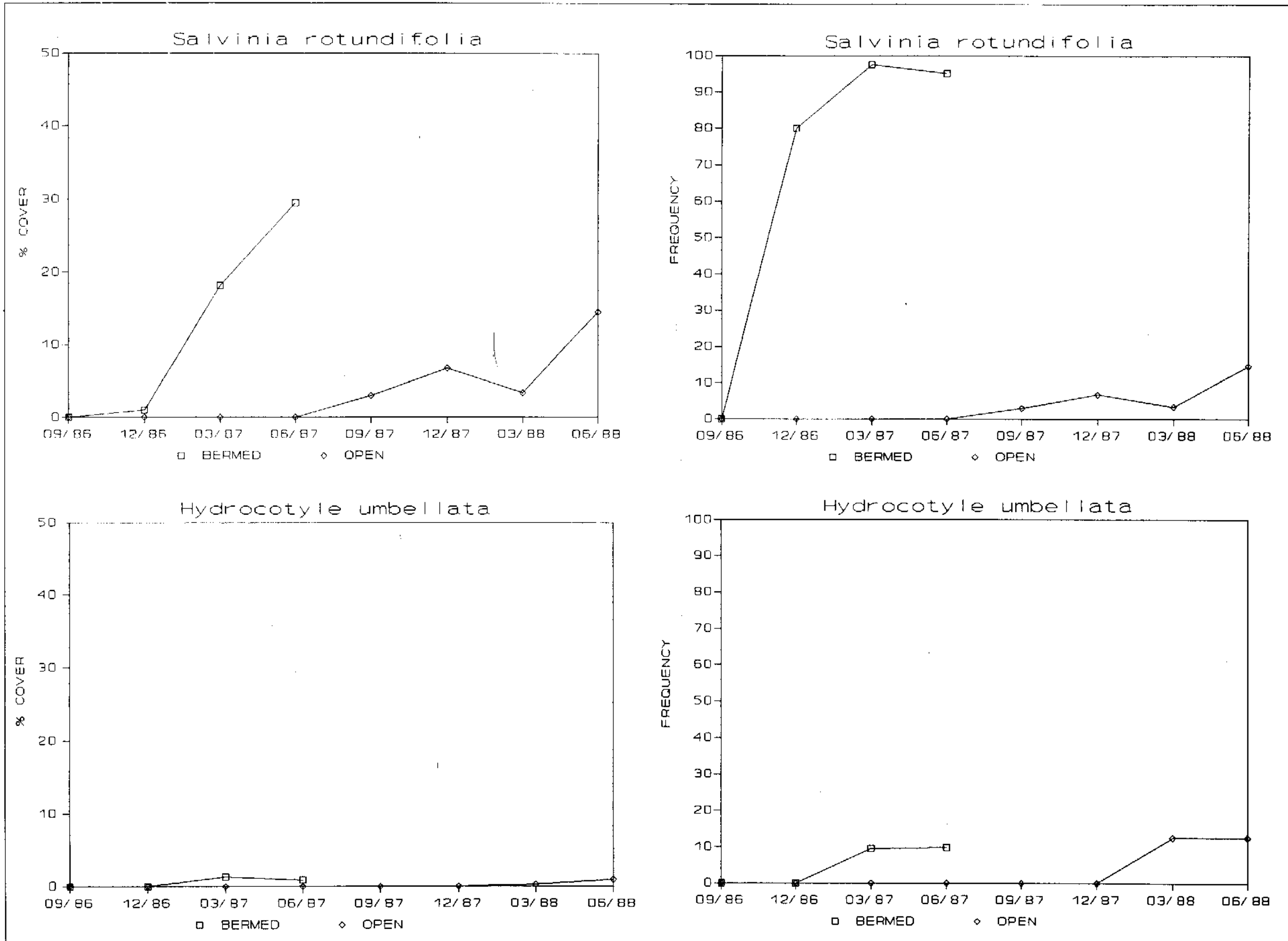

Salvinia rotundifolia
% COVER
0
10
20
30
40
50
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Salvinia rotundifolia
FREQUENCY
0
10
20
30
40
50
60
70
80
90
100
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Hydrocotyle umbellata
% COVER
0
10
20
30
40
50
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Hydrocotyle umbellata
FREQUENCY
0
10
20
30
40
50
60
70
80
90
100
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN

FIGURE 4C.

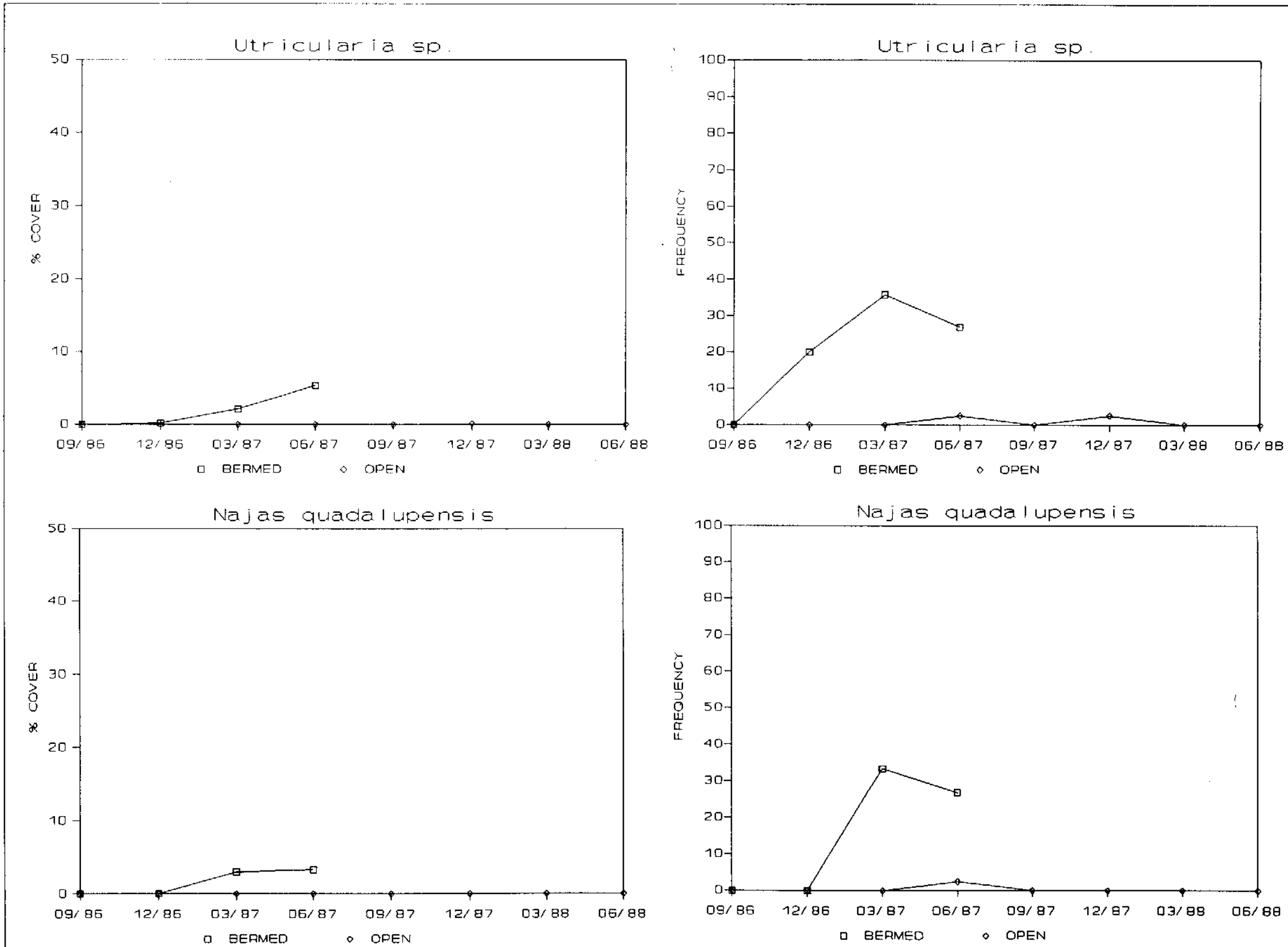

Utricularia sp.
% COVER
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Utricularia sp.
FREQUENCY
100
90
80
70
60
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Najas quadalupensis
% COVER
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Najas quadalupensis
FREQUENCY
100
90
80
70
60
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN

FIGURE 4D.

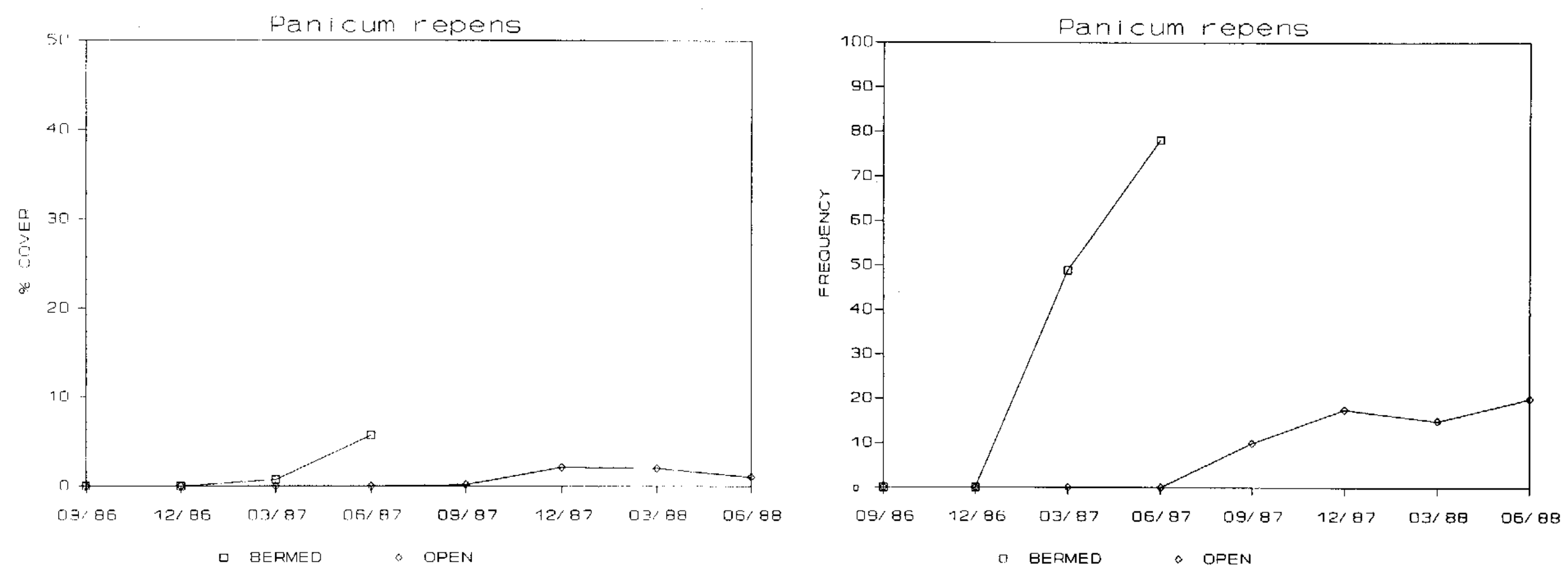

Panicum repens
% COVER
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN
Panicum repens
FREQUENCY
100
90
80
70
60
50
40
30
20
10
0
09/86
12/86
03/87
06/87
09/87
12/87
03/88
06/88
BERMED
OPEN

FIGURE 4E.

Eichhornia crassipes at times is found in association with a large variety of aquatic and marsh plants. Under different conditions it may form dense, mono-specific mats excluding all other free-floating and submerged plants, thus making it difficult to recognize definite plant associations (Gopal, 1977). Because of these dense, impenetrable mats, Eichhornia crassipes is considered to be one of the most serious aquatic weed problem species worldwide (Pieterse, 1978). It has proven to be a significant economic burden to many tropical and subtropical regions of the world where open water is desired (Penfound and Earle, 1948; Holm, Weldon and Blackburn, 1969). Eichhornia crassipes is a targeted species for weed control in the South Florida canal system.

Hydrilla spp. initially colonized the newly created shelf and quickly established dense patches (Figure 4a). As the coverage and frequency of Eichhornia crassipes increased, coverage of Hydrilla spp. decreased. Pistia stratiotes, Alternanthera philoxeroides, Salvinia rotundifolia, Hydrocotyle umbellata, and Panicum repens all displayed growth patterns similar to Eichhornia crassipes. Floating vegetation including Salvinia rotundifolia and to a lesser extent Pistia stratiotes, also was found inhabiting the Eichhornia crassipes community. Alternanthera philoxeroides and Hydrocotyle umbellata, normally rooted emergents, appeared to grow hydroponically amongst Eichhornia crassipes. Panicum repens also was found growing among Eichhornia crassipes, expanding its range along shallow portions of the shelf. Utricularia spp. and Najas quadalupensis were established outside the Eichhornia crassipes area of coverage.

Vegetation cover was less upstream than downstream in the open shelf. Canal 51 curves as it passes the shelf study area (Figure 2), and the vegetation coverage is greatest where the first berm island begins. This curving of the canal as it passes the shelf study area acts to trap the floating vegetation and debris onto the bermed shelf and continues onto the open shelf.

Total benthic macroinvertebrate numbers collected and pooled from September, 1986, to June, 1987, and from September, 1987, to June, 1988, are significantly different between the canal and open shelf (Table 2).

TABLE 2. Mean (arithmetic) densities of benthic macroinvertebrates from three sites in Canal 51. Values followed by the same letter are not significantly (P<0.05) different in rows.

		SITES		
		Open	Bermed	Canal
Chironomidae spp.	Sept 86 - June 87	168a	82b	26b
	Sept 87 - June 88	11a		50b
Oligochaeta	Sept 86 - June 87	78a	8b	16c
	Sept 87 - June 88	43a		55a
Totals	Sept 86 - June 87	268a	148a	71a
	Sept 87 - June 88	79a		140b

Chironomidae (47.3 %) and Oligochaeta (28.8 %) were the dominant organisms collected in terms of numbers. Highest total invertebrate densities in the open shelf occurred in December, 1986, and March and June, 1987, with decreasing densities occurring during all following collections (Figure 5a). From the fifth collection (September 87) to the last (June 88), the total numbers of organisms collected on the open shelf were significantly less than those collected in the canal (Table 2). Temporal variation in densities were not as great in the canal. During this same period, Eichhornia crassipes increased in coverage from 12 to 63 percent. Analysis revealed an inverse relationship between Eichhornia crassipes coverage and benthic organism abundance (Figure 5b). Low dissolved oxygen levels have been associated with Eichhornia crassipes vegetation mats (Abu-Gideiri and Yousif, 1974; McVea and Boyd, 1975; Rai and DattaMunshi, 1978; Reddy et al., 1983; Wahlquist, 1972). The shallow open shelf may have experienced a reduced number of organisms due to low oxygen levels caused by the increased coverage of Eichhornia crassipes.

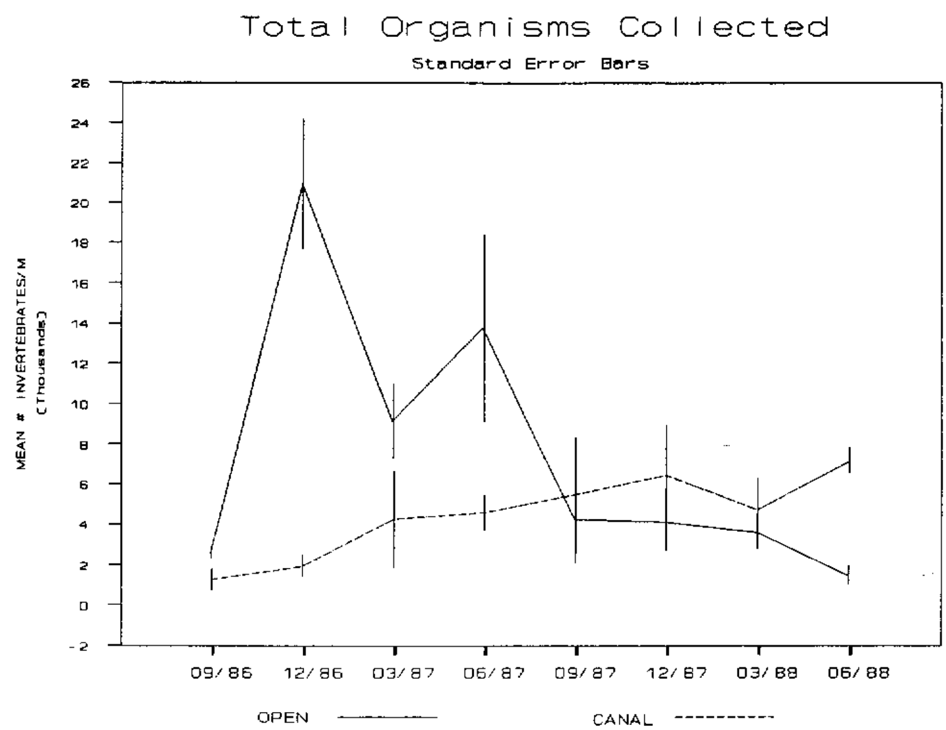


FIGURE 5a. Mean Density of Organisms for Study Duration

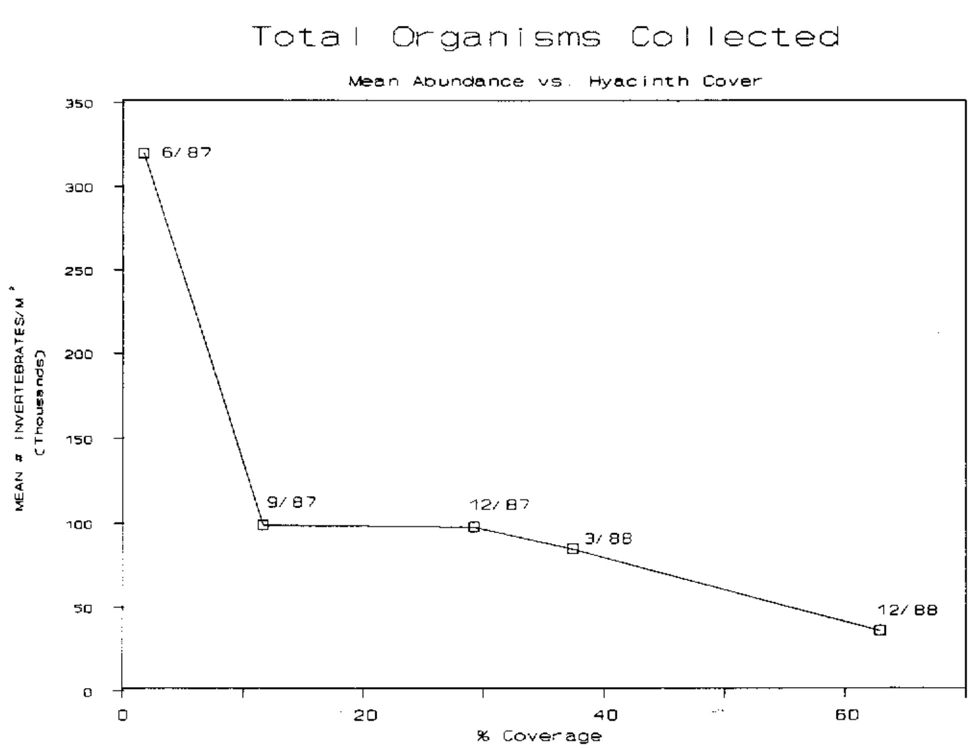


FIGURE 5B. Mean Density of Total Organisms Verses *Eichhornia crassipes* Vegetation Coverage in the Open Shelf

CONCLUSIONS

1. Bermed shelves were undesirable due to erosion and entrapment of debris and floating vegetation (especially Eichhornia crassipes).

2. Eichhornia crassipes rapidly colonized the open shelf, reaching 63 percent coverage in two years and Eichhornia crassipes was the dominant plant species observed. As Eichhornia crassipes coverage increased, total benthic organisms decreased. From the fifth collection (September 87) to the last (June 88), total organisms collected on the open shelf were less than those collected in the canal.

3. This study clearly showed that Eichhornia crassipes would be the dominant species in a littoral shelf environment if herbicidal control is eliminated and the shelf was left to naturally colonize.

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APPENDIX TABLE 1. Frequency and Cover of Dominant Vegetation Species Observed at Bermed and Open Shelves. Dominant is all Vegetation Found that had Cover Greater than one Percent.

Eichhornia crassipes

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	5.29	0.39	20.00	2.50
03/87	35.26	0.00	87.80	0.00
06/87	63.45	1.58	92.68	2.50
09/87		11.45		15.00
12/87		29.01		40.00
03/88		37.20		52.50
06/88		62.66		70.00

Hydrilla verticillata

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.25	0.01	38.10	2.50
12/86	10.85	0.49	82.50	47.50
03/87	5.95	0.38	56.10	25.00
06/87	2.13	1.13	24.39	25.00
09/87		10.89		77.50
12/87		10.43		60.00
03/88		0.19		25.00
06/88		0.00		0.00

Pistia Stratiotes

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.01	0.00	2.50
12/86	0.96	0.00	42.50	0.00
03/87	1.83	0.00	85.37	0.00
06/87	1.77	0.00	60.98	0.00
09/87		0.23		20.00
12/87		0.88		37.50
03/88		0.58		27.50
06/88		0.85		32.50

Alternanthera philoxeroides

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.05	0.00	9.52	0.00
12/86	0.44	0.04	62.50	7.50
03/87	2.28	0.03	90.24	5.00
06/87	1.04	0.00	85.37	0.00
09/87		1.46		17.50
12/87		0.76		27.50
03/88		0.68		22.50
06/88		0.78		42.50

Salvinia rotundifolia

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	1.03	0.00	80.00	0.00
03/87	18.17	0.00	97.56	0.00
06/87	29.50	0.01	95.12	2.50
09/87		2.98		82.50
12/87		6.75		37.50
03/88		3.36		22.50
06/88		14.53		30.00

Hydrocotyle umbellata

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00
03/87	1.30	0.00	9.52	0.00
06/87	0.90	0.00	9.76	0.00
09/87		0.00		0.00
12/87		0.00		0.00
03/88		0.25		12.50
06/88		0.94		12.50

Utricularia sp.

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	0.16	0.00	20.00	0.00
03/87	2.14	0.00	35.71	0.00
06/87	5.32	0.01	26.83	2.50
09/87		0.00		0.00
12/87		0.08		2.50
03/88		0.00		0.00
06/88		0.00		0.00

Najas quadalupensis

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00
03/87	3.02	0.00	33.33	0.00
06/87	3.30	0.01	26.83	2.50
09/87		0.00		0.00
12/87		0.00		0.00
03/88		0.00		0.00
06/88		0.00		0.00

Panicum repens

	% COVER		FREQUENCY	
	B	O	B	O
09/86	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00
03/87	0.73	0.00	48.78	0.00
06/87	5.70	0.00	78.05	0.00
09/87		0.18		10.00
12/87		2.15		17.50
03/88		2.01		15.00
06/88		1.04		20.00

B - Bermed
O - Open

APPENDIX TABLE 2. Frequency and Cover of Other Vegetation Species Observed at Bermed and Open Shelves.

	Chara sp.				Ceratophyllum demersum				Cambomba pulcherrima				Colocasia esculentum			
	% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY	
	B	O	B	O	B	O	B	O	B	O	B	O	B	O	B	O
09/86	0.05	0.01	9.52	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12/86	0.01	0.10	2.50	7.50	0.84	0.00	55.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/87	0.00	0.00	0.00	0.00	0.44	0.08	26.83	2.50	0.01	0.00	2.38	0.00	0.07	0.00	14.63	0.00
06/87	0.00	0.00	0.00	0.00	0.77	0.01	19.51	2.50	0.00	0.00	0.00	0.00	0.10	0.00	7.32	0.00
09/87		0.00		0.00		0.39		27.50		0.00		0.00		0.00		0.00
12/87		0.00		0.00		0.35		20.00		0.00		0.00		0.00		0.00
03/88		0.00		0.00		0.01		2.50		0.00		0.00		0.10		7.50
06/88		0.00		0.00		0.00		0.00		0.00		0.00		0.03		5.00

	Commelina diffusa				Eleocharis baldwinii				Galium sp.				Ludwigia sp.			
	% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY	
	B	O	B	O	B	O	B	O	B	O	B	O	B	O	B	O
09/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/87	0.14	0.00	4.76	0.00	0.08	0.00	4.76	0.00	0.01	0.00	2.38	0.00	0.00	0.00	0.00	0.00
06/87	0.02	0.00	4.88	0.00	0.85	0.00	24.39	0.00	0.01	0.00	2.44	0.00	0.28	0.00	31.71	0.00
09/87		0.00		0.00		0.00		0.00		0.00		0.00		0.01		2.50
12/87		0.08		2.50		0.00		0.00		0.00		0.00		0.00		0.00
03/88		0.40		5.00		0.00		0.00		0.00		0.00		0.00		0.00
06/88		0.40		5.00		0.00		0.00		0.00		0.00		0.00		0.00

	Ipomea sp.				Cyperus papyrus				Panicum purpurascens				Ludwigia octovalis			
	% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY	
	B	O	B	O	B	O	B	O	B	O	B	O	B	O	B	O
09/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/87	0.07	0.00	2.44	0.00	0.46	0.00	7.32	0.00	0.17	0.00	9.76	0.00	0.93	0.00	2.44	0.00
09/87		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
12/87		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
03/88		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
06/88		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00

	Cyperus odoratus				Nymphoides sp.				Typha sp.			
	% COVER		FREQUENCY		% COVER		FREQUENCY		% COVER		FREQUENCY	
	B	O	B	O	B	O	B	O	B	O	B	O
09/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12/86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/87	0.01	0.00	2.44	0.00	0.15	0.01	4.88	2.50	0.00	0.00	0.00	0.00
09/87		0.00		0.00		0.00		0.00		0.00		0.00
12/87		0.00		0.00		0.00		0.00		0.01		2.50
03/88		0.00		0.00		0.00		0.00		0.01		2.50
06/88		0.00		0.00		0.00		0.00		0.00		0.00

B - Bermed
O - Open

APPENDIX TABLE 3. Means and Standard Errors for Benthics Collected in Canal, Bermed (B) and Open (O) Sites

Total Benthics Collected

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	30.8	12.9	60.7	6.9	31.3	20.1
12/86	46.7	13.2	486.2	75.1	403.2	166.0
03/87	100.5	55.7	212.5	42.7	121.8	52.4
06/87	107.7	20.5	320.2	107.9	37.0	6.9
09/87	128.2	67.1	99.3	50.9		
12/87	152.3	56.1	97.7	35.8		
03/88	111.5	36.1	84.8	19.7		
06/88	168.3	14.9	34.7	11.2		

Chironomidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	3.0	0.7	56.8	6.1	29.5	19.2
12/86	16.7	4.6	346.8	61.6	244.0	123.3
03/87	50.5	23.7	104.7	29.4	52.0	30.0
06/87	44.0	9.6	201.5	72.7	3.8	0.4
09/87	23.7	7.2	12.8	4.7		
12/87	29.2	10.7	9.3	4.8		
03/88	35.2	8.5	17.2	9.7		
06/88	55.2	11.1	5.3	3.0		

Hirudinea

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.2	0.2	0.0	0.0	3.8	2.8
03/87	1.2	1.2	0.2	0.2	7.0	6.4
06/87	0.5	0.2	0.2	0.2	0.2	0.2
09/87	0.0	0.0	0.0	0.0		
12/87	0.3	0.3	1.0	0.5		
03/88	4.0	3.6	0.2	0.2		
06/88	2.0	1.3	0.5	0.2		

Oligochaeta

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	24.3	12.1	3.2	1.4	0.2	0.2
12/86	8.8	3.5	128.2	20.9	3.3	1.5
03/87	15.7	6.4	96.2	16.5	22.5	12.7
06/87	16.8	2.4	95.2	28.2	7.2	4.8
09/87	73.2	46.8	59.7	33.4		
12/87	109.8	44.2	42.5	14.4		
03/88	18.3	8.5	46.0	21.4		
06/88	20.3	3.0	24.0	9.2		

Cladocera

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.5	0.2	0.3	0.2	1.0	0.5
12/86	0.2	0.2	0.2	0.2	26.8	16.6
03/87	0.0	0.0	0.0	0.0	1.0	0.5
06/87	0.2	0.2	0.8	0.8	0.2	0.2
09/87	1.0	0.5	1.3	1.3		
12/87	1.0	0.4	0.3	0.2		
03/88	1.0	0.4	0.3	0.2		
06/88	0.5	0.3	0.3	0.2		

Copepoda

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	1.2	0.5	0.0	0.0	0.5	0.5
12/86	1.0	0.8	0.2	0.2	6.0	4.2
03/87	2.5	1.0	0.0	0.0	2.3	2.1
06/87	8.2	5.6	0.5	0.5	0.2	0.2
09/87	12.2	6.4	0.0	0.0		
12/87	2.8	1.1	5.7	4.4		
03/88	4.8	1.2	1.0	1.0		
06/88	27.2	4.1	1.5	1.0		

Ostracoda

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	1.0	0.5	0.5	0.2	9.7	8.7
03/87	19.3	16.6	1.0	0.4	9.3	8.3
06/87	5.0	3.1	1.0	0.8	12.2	8.2
09/87	9.2	7.0	9.5	8.9		
12/87	3.7	1.3	6.7	4.3		
03/88	20.7	8.1	0.7	0.3		
06/88	52.2	8.4	1.0	0.5		

Taphromysis louisianae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	1.0	0.5	0.0	0.0
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.2	0.2	0.2	0.2	0.0	0.0
09/87	0.2	0.2	0.2	0.2		
12/87	0.2	0.2	0.2	0.2		
03/88	0.0	0.0	0.0	0.0		
06/88	0.3	0.2	0.2	0.2		

APPENDIX TABLE 4. Means and Standard Errors for Benthics Collected in Canal, Bermed (B) and Open (O) Sites

Isopoda

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.2	0.2	0.0	0.0	0.3	0.3
03/87	0.3	0.2	0.0	0.0	0.0	0.0
06/87	0.2	0.2	0.0	0.0	0.0	0.0
09/87	0.2	0.2	0.0	0.0		
12/87	0.3	0.2	0.0	0.0		
03/88	1.8	0.6	0.0	0.0		
06/88	0.3	0.2	0.0	0.0		

Gammarus

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.8	0.3	0.0	0.0	0.0	0.0
12/86	0.5	0.3	0.0	0.0	0.0	0.0
03/87	1.7	1.7	0.0	0.0	0.0	0.0
06/87	1.8	1.6	0.2	0.2	0.0	0.0
09/87	0.0	0.0	0.0	0.0		
12/87	0.7	0.7	0.0	0.0		
03/88	14.0	6.2	0.0	0.0		
06/88	1.0	0.4	0.0	0.0		

Hyalella azteca

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	1.3	1.3	0.0	0.0	14.2	7.9
03/87	0.5	0.5	0.2	0.2	4.5	1.5
06/87	1.5	0.9	1.2	1.0	1.8	1.6
09/87	0.2	0.2	7.5	5.5		
12/87	0.5	0.3	25.8	15.8		
03/88	6.7	6.7	8.2	7.4		
06/88	0.2	0.2	1.3	0.8		

Palaemonetes paludosus

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.0	0.0
03/87	0.0	0.0	0.0	0.0	0.3	0.2
06/87	0.0	0.0	0.0	0.0	0.0	0.0
09/87	0.0	0.0	0.2	0.2		
12/87	0.0	0.0	0.3	0.3		
03/88	0.2	0.2	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Hydracarina

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	1.0	0.8
03/87	0.0	0.0	0.0	0.0	0.2	0.2
06/87	0.0	0.0	0.0	0.0	0.0	0.0
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	0.2	0.2		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Collembola

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.5	0.5
03/87	0.0	0.0	0.0	0.0	0.2	0.2
06/87	0.0	0.0	0.0	0.0	2.3	1.3
09/87	0.0	0.0	0.0	0.0		
12/87	0.2	0.2	0.0	0.0		
03/88	0.0	0.0	6.2	2.9		
06/88	0.0	0.0	0.0	0.0		

Callibaetis

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.2	0.2	2.2	1.5
03/87	0.0	0.0	0.0	0.0	1.5	0.8
06/87	0.0	0.0	0.0	0.0	0.0	0.0
09/87	0.0	0.0	0.2	0.2		
12/87	0.3	0.2	1.5	0.7		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Caenis sp.

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.2	0.2	0.2	0.2
12/86	0.7	0.5	2.7	1.0	68.8	41.8
03/87	1.5	1.3	1.0	1.0	7.3	6.3
06/87	5.2	3.3	6.3	6.1	0.3	0.2
09/87	1.3	0.6	3.0	2.6		
12/87	1.5	0.6	0.5	0.3		
03/88	2.0	1.5	1.5	1.5		
06/88	0.2	0.2	0.0	0.0		

APPENDIX TABLE 5. Means and Standard Errors for Benthics Collected in Canal, Bermed (B) and Open (O) Sites

Odonata

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.3	0.2	0.2	0.2	0.0	0.0
12/86	5.3	3.2	0.2	0.2	1.8	1.0
03/87	0.0	0.0	0.0	0.0	1.2	0.7
06/87	0.2	0.2	0.0	0.0	1.8	0.9
09/87	0.0	0.0	0.7	0.5		
12/87	0.2	0.2	0.8	0.5		
03/88	0.2	0.2	0.3	0.2		
06/88	0.0	0.0	0.0	0.0		

Coroxidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.2	0.2
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.0	0.0	0.0	0.0	0.2	0.2
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	0.0	0.0		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Coleoptera

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.3	0.3
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.0	0.0	0.2	0.2	0.3	0.2
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	0.0	0.0		
03/88	0.0	0.0	0.2	0.2		
06/88	0.0	0.0	0.0	0.0		

Ceratopogonidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.8	0.7	1.5	1.0	6.2	5.2
03/87	0.2	0.2	0.5	0.3	2.5	1.1
06/87	1.2	0.5	2.3	2.1	0.5	0.2
09/87	0.8	0.5	0.5	0.2		
12/87	0.3	0.2	0.2	0.2		
03/88	0.0	0.0	0.0	0.0		
06/88	0.3	0.2	0.0	0.0		

Hemiptera

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.2	0.2	0.0	0.0
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.0	0.0	0.0	0.0	0.2	0.2
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	0.0	0.0		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Hydroptilidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.8	0.7
03/87	0.0	0.0	0.0	0.0	0.5	0.5
06/87	0.0	0.0	0.2	0.2	0.0	0.0
09/87	0.0	0.0	0.2	0.2		
12/87	0.0	0.0	0.2	0.2		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Culicidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.2	0.2
03/87	0.2	0.2	0.0	0.0	0.0	0.0
06/87	0.2	0.2	0.0	0.0	1.2	0.6
09/87	4.5	2.0	0.0	0.0		
12/87	0.2	0.2	0.0	0.0		
03/88	0.3	0.3	0.0	0.0		
06/88	5.5	3.0	0.0	0.0		

Gastropoda - Unidentified

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.8	0.5	0.2	0.2	6.5	3.7
03/87	1.7	1.5	0.5	0.2	7.7	4.6
06/87	0.0	0.0	0.5	0.5	4.0	1.6
09/87	0.3	0.2	3.0	1.6		
12/87	0.3	0.2	0.8	0.4		
03/88	1.3	1.0	2.0	1.4		
06/88	0.2	0.2	0.2	0.2		

APPENDIX TABLE 6. Means and Standard Errors for Benthics Collected in Canal, Bermed (B) and Open (O) Sites

Ancylidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.2	0.2
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.0	0.0	0.0	0.0	0.0	0.0
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	1.2	0.8		
03/88	0.0	0.0	0.3	0.3		
06/88	0.0	0.0	0.2	0.2		

Melanoides turricula

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B
09/86	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.2
03/87	0.0	0.0	0.0	0.0	0.0
06/87	0.0	0.0	0.3	0.2	0.2
09/87	0.0	0.0	0.0	0.0	
12/87	0.0	0.0	0.2	0.2	
03/88	0.0	0.0	0.5	0.3	
06/88	0.0	0.0	0.0	0.0	

Viviparus georgianus

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.3	0.2	0.2	0.2	0.0	0.0
03/87	0.0	0.0	0.3	0.3	0.0	0.0
06/87	1.3	0.5	0.2	0.2	0.0	0.0
09/87	0.5	0.2	0.0	0.0		
12/87	0.3	0.2	0.0	0.0		
03/88	0.0	0.0	0.0	0.0		
06/88	0.2	0.2	0.0	0.0		

Sphaeriidae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B
09/86	0.5	0.2	0.0	0.0	0.0
12/86	8.8	6.1	2.0	0.6	4.0
03/87	3.3	2.6	4.7	2.7	0.7
06/87	17.3	5.4	0.2	0.2	0.0
09/87	0.8	0.8	0.0	0.0	
12/87	0.3	0.2	0.0	0.0	
03/88	0.5	0.5	0.2	0.2	
06/88	2.0	1.0	0.2	0.2	

Unionadae

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.0	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.0	0.0	0.0	0.0
03/87	0.0	0.0	0.0	0.0	0.0	0.0
06/87	0.3	0.2	0.0	0.0	0.0	0.0
09/87	0.0	0.0	0.0	0.0		
12/87	0.0	0.0	0.0	0.0		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

Corbicula manilensis

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B
09/86	0.0	0.0	0.0	0.0	0.0
12/86	0.0	0.0	1.7	0.8	1.0
03/87	2.0	1.3	3.0	1.5	1.2
06/87	3.3	1.8	9.3	4.4	0.2
09/87	0.0	0.0	0.7	0.4	
12/87	0.2	0.2	0.3	0.2	
03/88	0.5	0.3	0.2	0.2	
06/88	0.8	0.7	0.0	0.0	

Nemotoda

	MEAN CANAL	STAN. ERROR	MEAN O	STAN. ERROR	MEAN B	STAN. ERROR
09/86	0.2	0.2	0.0	0.0	0.0	0.0
12/86	0.0	0.0	0.7	0.3	1.2	1.0
03/87	0.0	0.0	0.3	0.2	0.0	0.0
06/87	0.3	0.3	0.0	0.0	0.3	0.2
09/87	0.2	0.2	0.0	0.0		
12/87	0.0	0.0	0.0	0.0		
03/88	0.0	0.0	0.0	0.0		
06/88	0.0	0.0	0.0	0.0		

EXHIBIT 1

Background information on Canal 51 project

South Florida Water Management District

John R. Wodraska, Executive Director
Tilford C. Creel, Deputy Executive Director

Post Office Box V 3301 Gun Club Road
West Palm Beach, Florida 33402
Telephone (305) 686-8800
Florida WATS Line 1-800-432-2045

IN REPLY REFER TO:

3130/MP

September 24, 1985

Mr. Mike Nagy
Environmental Supervisor
Florida Department of
Environmental Regulation
2600 Blair Stone Road
Tallahassee, FL 32301

Dear Mr. ~~Nagy:~~ Mike

Subject: Special Condition to Permit #500877569

On July 18, 1985, this agency received the above DER permit to excavate a portion of the C-51 Canal in the vicinity of Forest Hill and Summit Boulevards, in West Palm Beach.

Specific condition No. 2 of that permit requires the creation of a littoral shelf along the eastern shore of the subject excavation area.

Please find enclosed four copies of signed and sealed engineering drawings, both plan view and cross sections. Additionally, a discussion of the proposed test project is included.

I trust that this satisfies the entent of special condition No. 2, however, if you should have any questions, please call.

Sincerely,

Paul Millar

Paul Millar
Project Analyst
Major Programs Division

PM/bh
Enclosures
cc: Alan Hall
Hans Ihle
Jan Horvath
Jim Milleson
Jeanne Hall

C-51/SUMMIT BLVD. LITTORAL ZONE CREATION

MAJOR PROGRAMS DIVISION

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SEPTEMBER, 1985

In July, 1985, the South Florida Water Management District received a permit from the Florida Department of Environmental Regulation to enlarge a section of C-51 from Summit Boulevard to Forest Hill Boulevard, within the city of West Palm Beach. The permit included a specific condition which required the creation of a littoral shelf along the eastern shoreline of the C-51 canal within the project area.

The issue of environmental enhancement, as it relates to the creation of littoral zone habitats along a canal bank, has been the recommendation of both regulatory agencies and contributors to the regulatory process. The environmental effectiveness of a littoral zone along a major urbanized drainage canal is not well documented. Therefore, one of the major reasons for the design of this littoral zone will be to monitor the area.

The purpose of this document is to detail the proposed littoral zone and subsequent monitoring program. The results of that monitoring and the access to the site itself will be made available to interested parties.

PROJECT AREA:

The area to be utilized for littoral zone creation lies within the existing District right-of-way on the east side of C-51 from a point 150 feet south of Summit Boulevard and continuing south approximately 900 feet.

LITTORAL ZONE DESIGN

The littoral zone area will be made up of 6 sections from north to south as follows:

1.)	10 foot wide	1 on 5 Slope	With No Protection Berm
2.)	20 foot wide	1 on 10 Slope	With No Protection Berm
3.)	30 foot wide	1 on 15 Slope	With No Protection Berm
4.)	30 foot wide	1 on 15 Slope	With Protection Berm
5.)	20 foot wide	1 on 10 Slope	With Protection Berm
6.)	10 foot wide	1 on 5 Slope	With Protection Berm

An on site inspection was made of the area on June 4, 1985 to examine the existing conditions of the property and to assist in developing a plan for this littoral zone. Special attention was made to designing around existing desirable vegetation (Sabal palmetto and Pinus elliottii) and the subsequent removal of exotics (Casuarina equisetifolia and Schinus terebinthifolius).

Following completion of the U. S. Army Corps of Engineers contract work within this area the eastern shoreline of C-51 will be sculptured to create two littoral shelf areas. The northern most area will contain 75 to 100 foot long segments of littoral shelves at 10 feet wide, 20 feet wide and 30 feet wide. The southern part of the right of way parcel will also contain three segments of varying widths, however the waterward edge of the shelf will be protected by placement of an earthern berm to reduce the energy from boat traffic and canal flows. Bottom levels will grade uniformly upward from 2 feet below mean water to the shoreline. Additionally, one deep hole, to be supplied with an artificial substrate "fish attractor" by the Game and Fish Commission, will be created in the southern area.

The area will not be selectively revegetated but will be allowed to revegetate naturally. One of the objectives of this test program will be to document the natural revegetation process.

MONITORING

It is proposed that a littoral shelf be created in this portion of C-51 to enable District scientists the opportunity to monitor the area. Several questions may be answered through a proper design and follow up observations of a created littoral shelf:

(1) What species of aquatic vegetation will colonize a shallow submergent shelf?

(2) What water depths are most readily colonized?

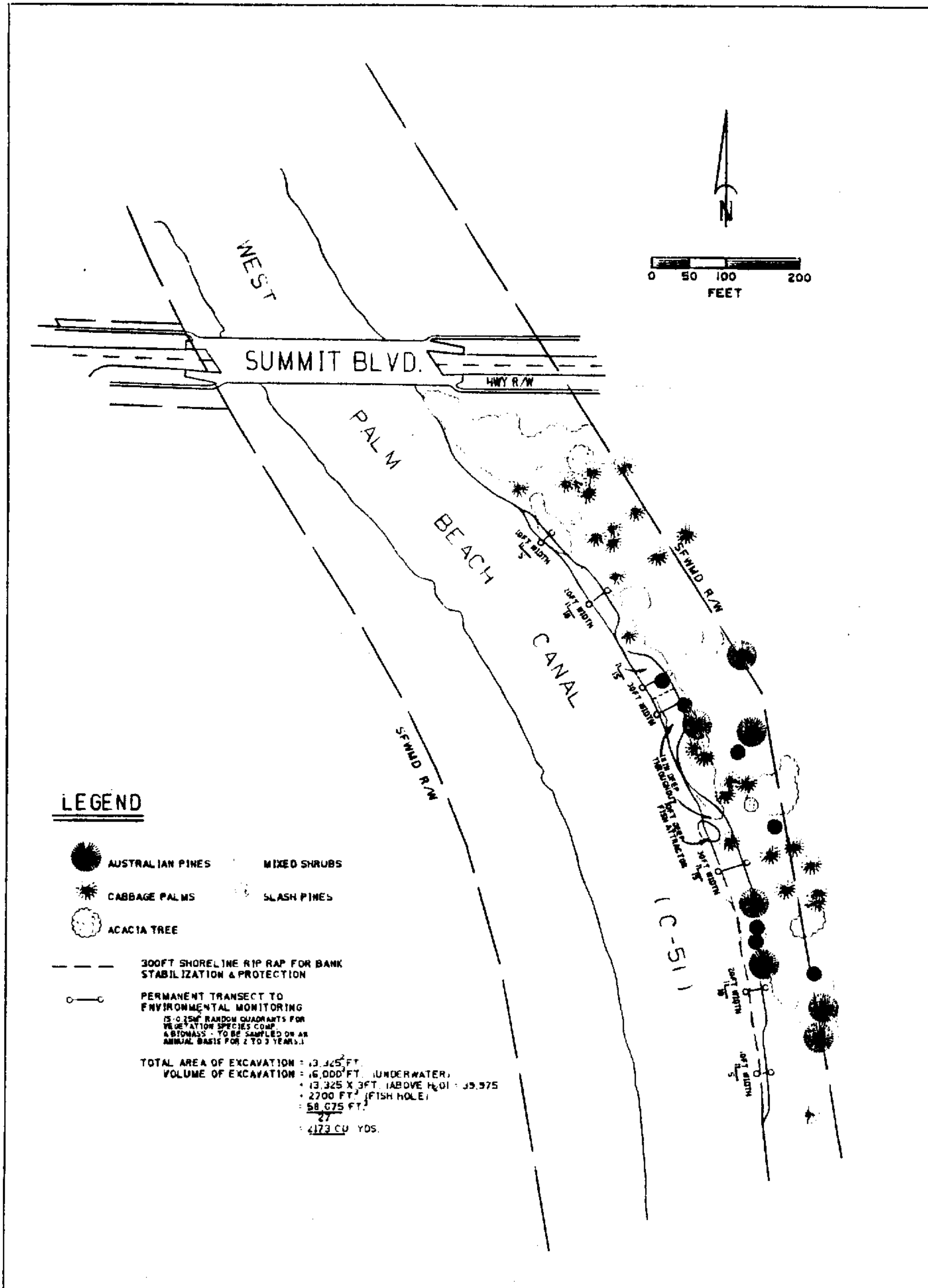
(3) Does the width of the littoral shelf affect the ability to (a) become colonized by aquatic vegetation or (b) become a shallow trap for floating trash and debris?

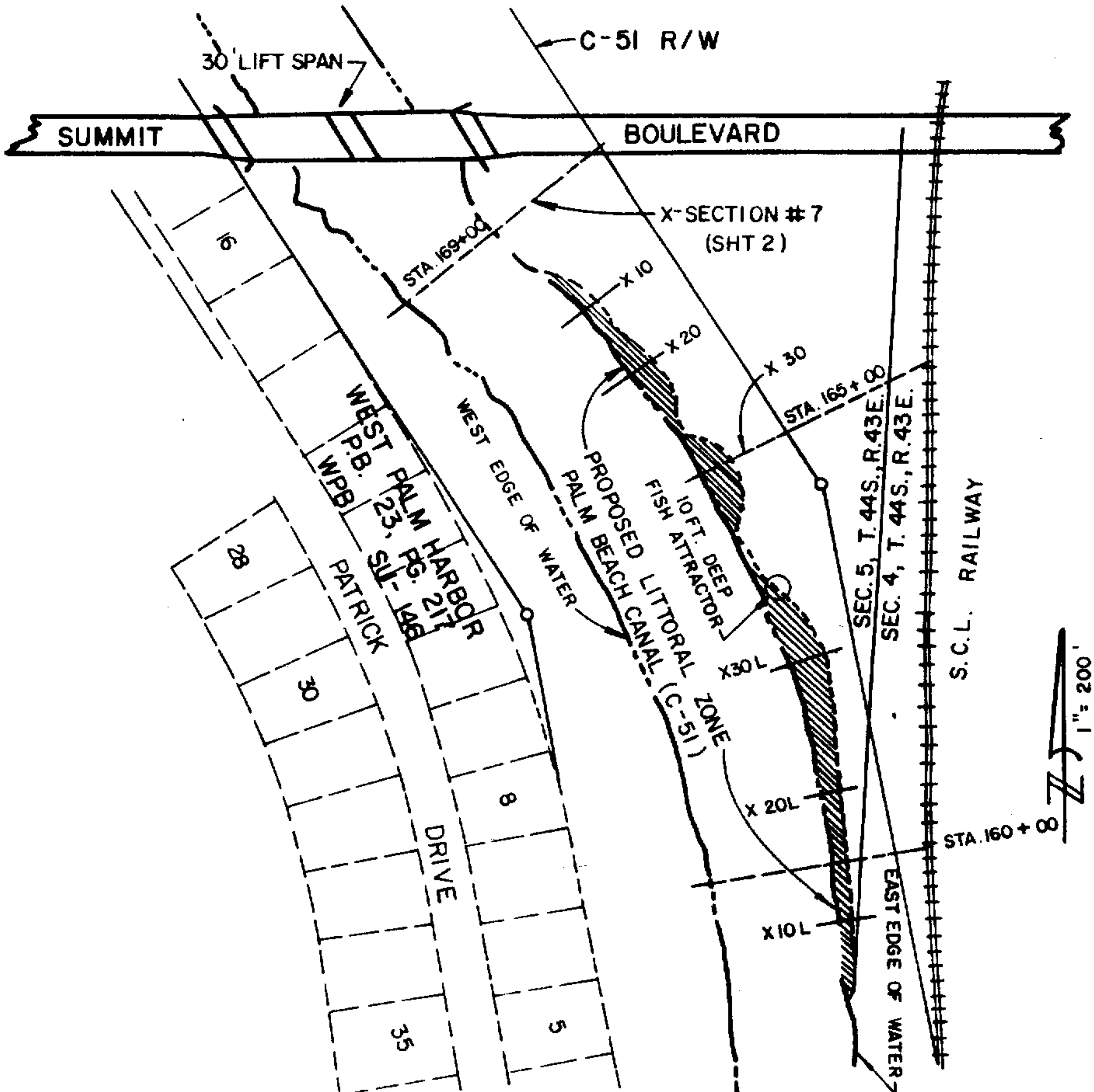
(4) Will nuisance aquatic vegetation become a problem?

(5) Is shoreline stabilization and protection required for littoral vegetation establishment?

DESIGN DRAWINGS:

Please find attached both the plan view and cross sectional drawings.


N
0 50 100 200
FEET
WEST PALM BEACH CANAL
SUMMIT BLVD.
HWY R/W
SFWMD R/W
SFWMD R/W
(C-51)
LEGEND
AUSTRALIAN PINES
MIXED SHRUBS
CABBAGE PALMS
SLASH PINES
ACACIA TREE
300FT SHORELINE RIP RAP FOR BANK STABILIZATION & PROTECTION
PERMANENT TRANSECT TO ENVIRONMENTAL MONITORING
(5-0.25M² RANDOM QUADRANTS FOR VEGETATION SPECIES COMP. & BIOMASS - TO BE SAMPLED ON AN ANNUAL BASIS FOR 2 TO 3 YEARS.)
TOTAL AREA OF EXCAVATION = 13,325 FT²
VOLUME OF EXCAVATION = 16,000 FT³ (UNDERWATER)
+ 13,325 X 3FT (ABOVE H₂O) = 39,975
+ 2700 FT³ (FISH HOLE)
= 58,675 FT³ / 27
= 2173 CU YDS.

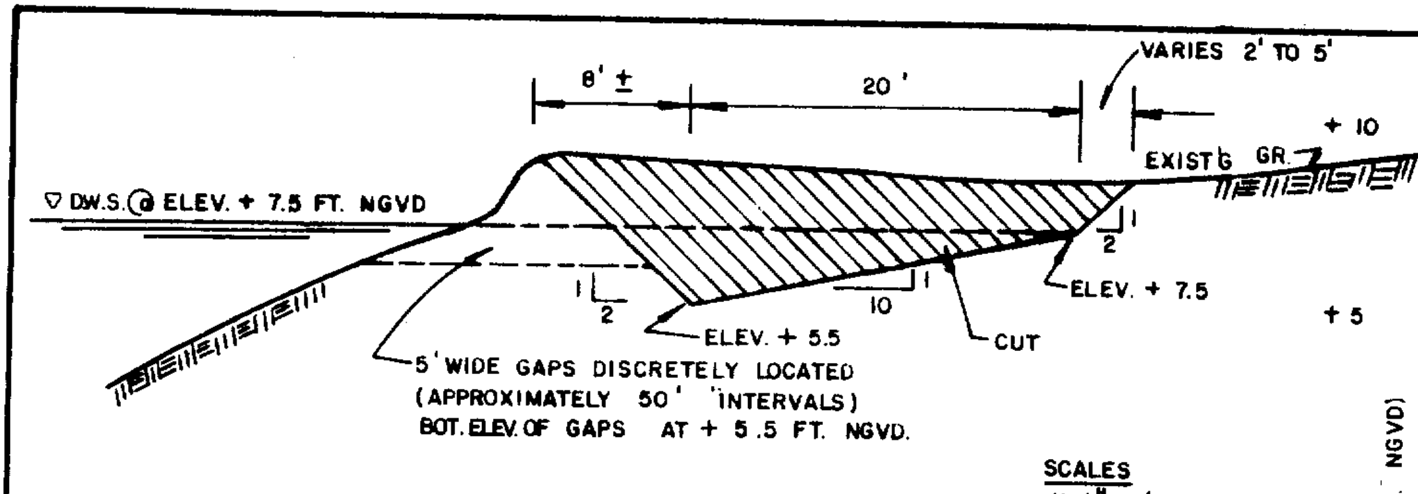


DESIGNED UNDER SUPERVISION
OF ROBERT E. RODGERS, P.E.
FLA. ENGINEER CERT. NO. 11572

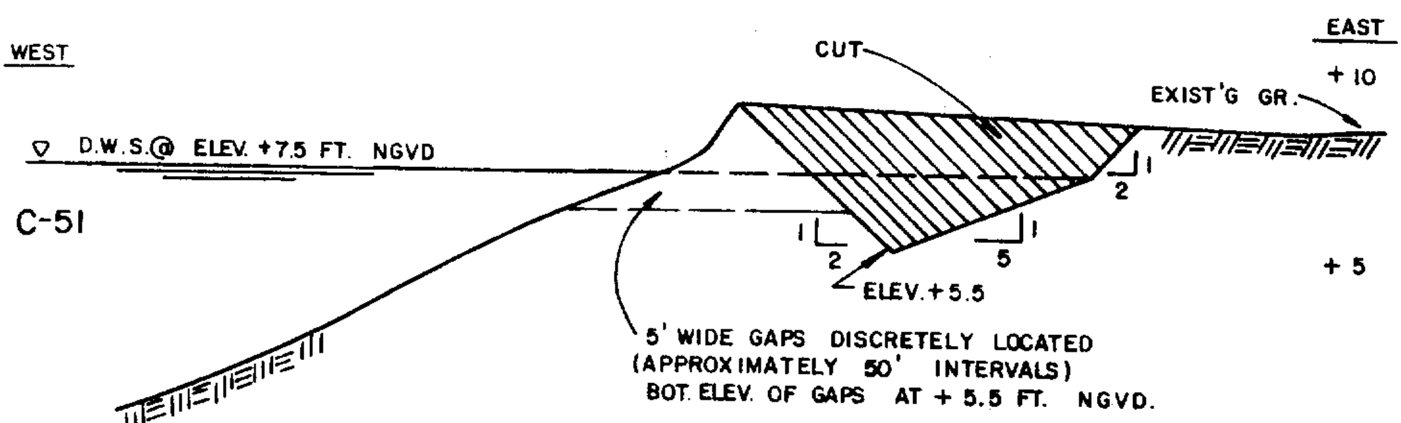
SOUTH FLORIDA WATER MANAGEMENT DIST.

C-51
WEST PALM BEACH CANAL
LITTORAL SHELF

9/18/85 C-51-SK-19 SHEET 1 OF 4



SECTION X 20 L
20 FT. LITTORAL ZONE W/LIP



SECTION X10L
10 FT. LITTORAL ZONE W/ LIP

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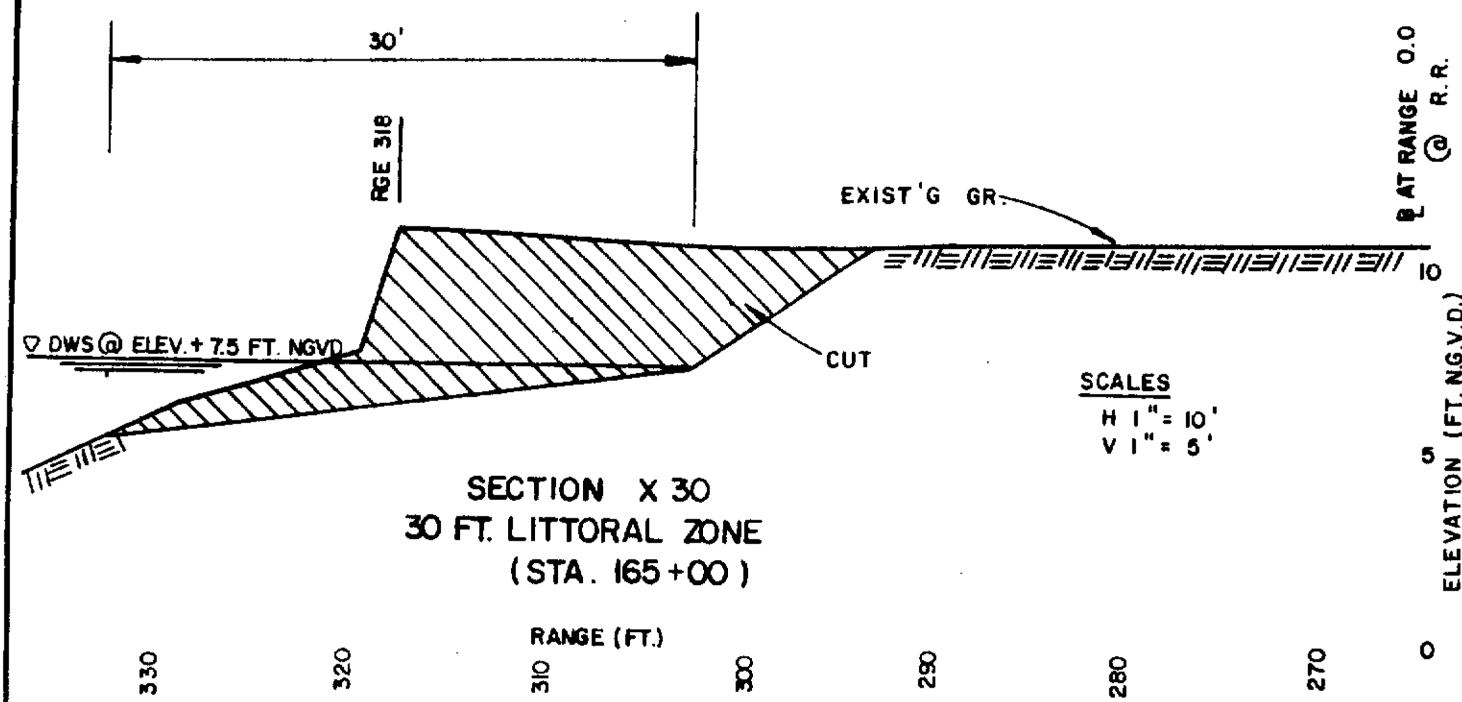
OF ROBERT E. RODGERS, P.E.
FLA. ENGINEER CERT. NO. 11572

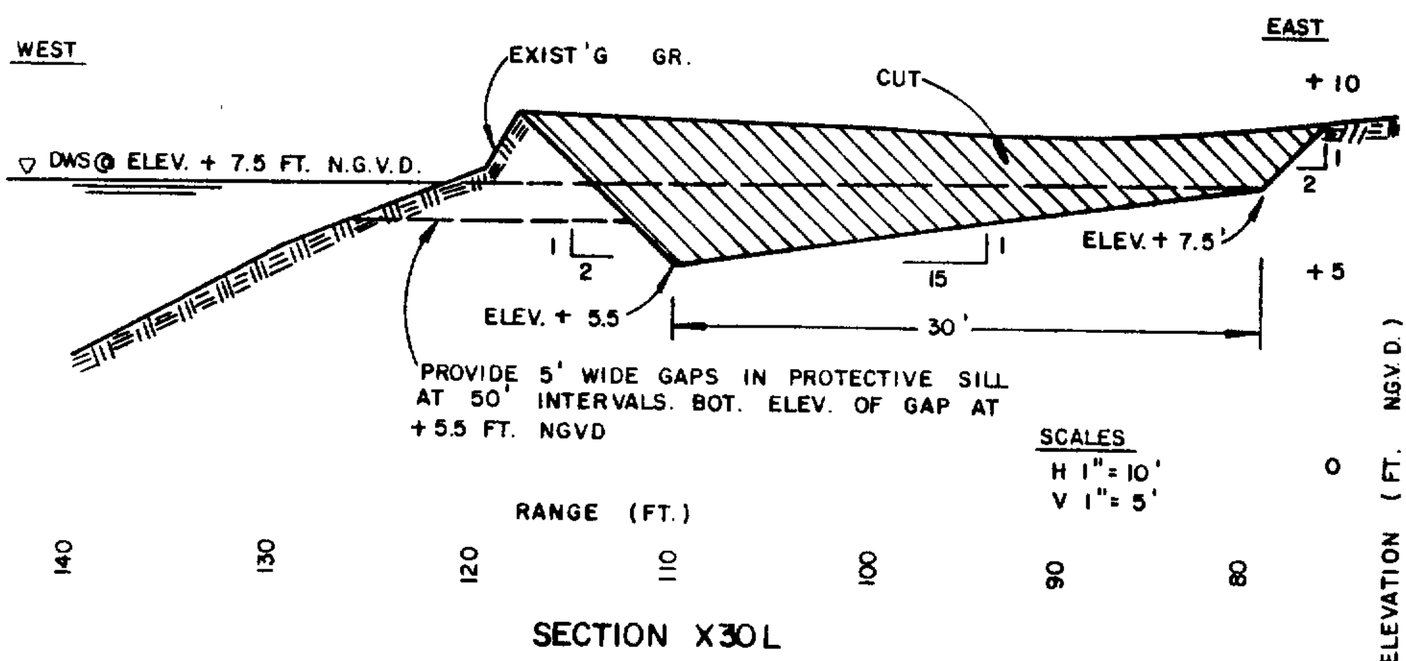
SOUTH FLORIDA WATER MANAGEMENT DIST.

C-51
WEST PALM BEACH CANAL
LITTORAL SHELF

9/18/85 C-51-SK-19 SHEET 2 OF 4



SECTION X 30
30 FT. LITTORAL ZONE
(STA. 165 + 00)



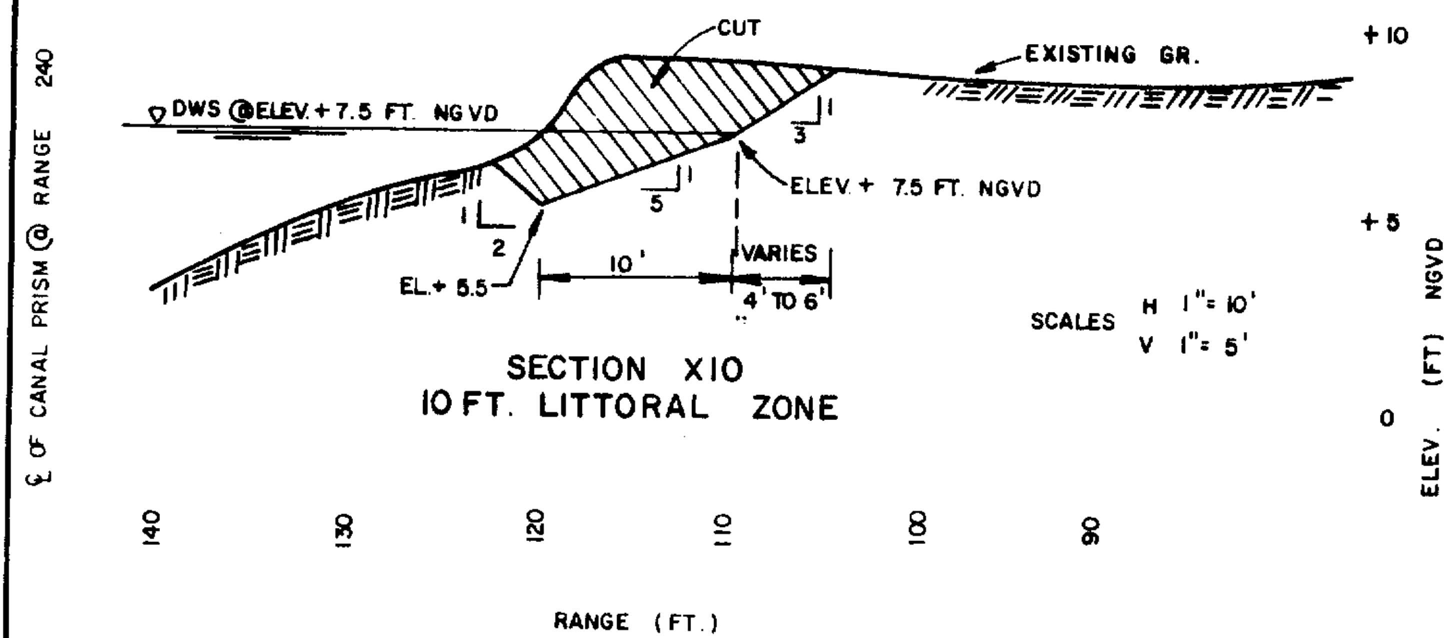
SECTION X30L
30 FT. LITTORAL ZONE W/LIP

DESIGNED UNDER SUPERVISION
OF ROBERT E. RODGERS, P.E.
FLA. ENGINEER CERT. NO. 11572

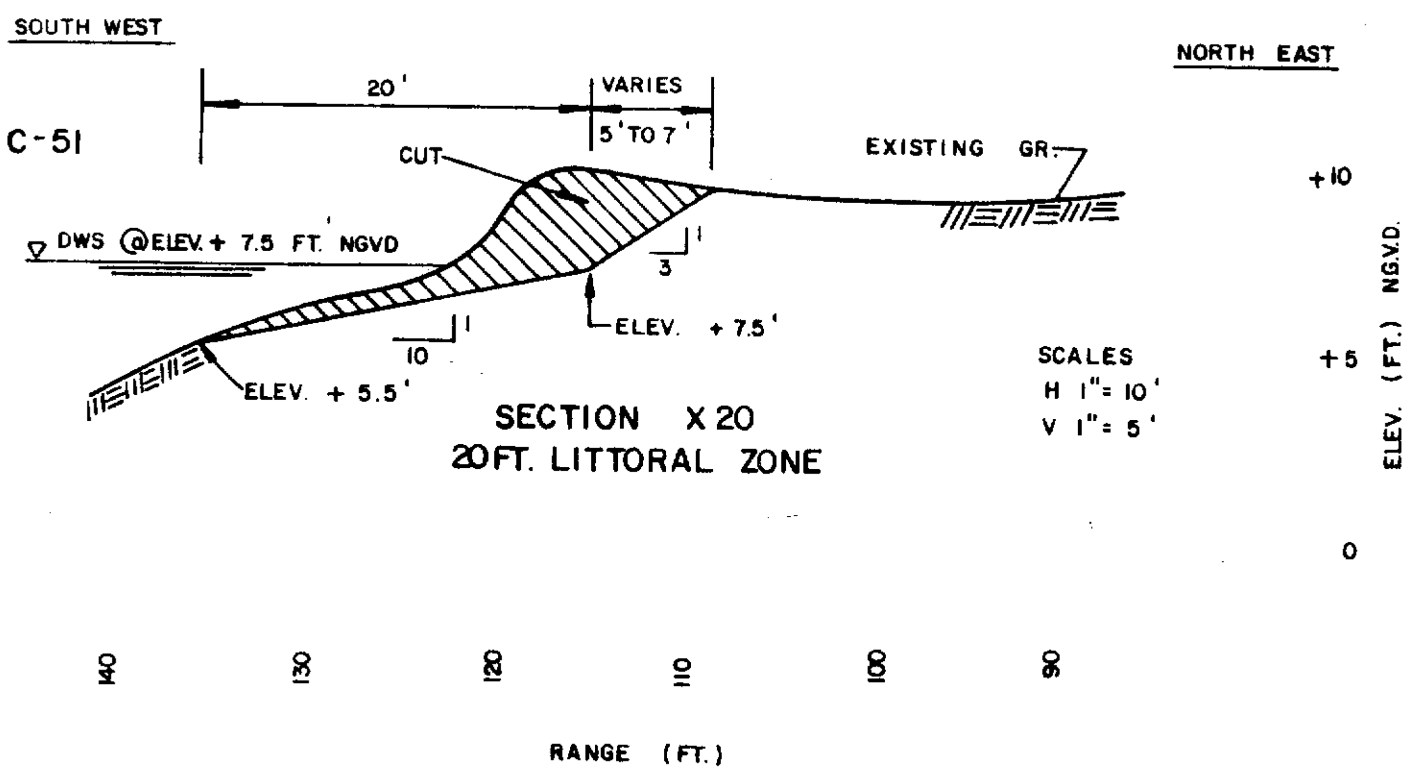
SOUTH FLORIDA WATER MANAGEMENT DIST.

C-51
WEST PALM BEACH CANAL
LITTORAL SHELF

9/18/85 C-51-SK-19 SHEET 3 OF 4



SECTION X10
10 FT. LITTORAL ZONE



SECTION X 20
20 FT. LITTORAL ZONE

DESIGNED UNDER SUPERVISION
OF ROBERT E. RODGERS, P.E.
FLA. ENGINEER CERT. NO. 11572

SOUTH FLORIDA WATER MANAGEMENT DIST.

C-51
WEST PALM BEACH CANAL
LITTORAL SHELF

9/18/85 C-51-SK-19 SHEET 4 OF 4

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301-8241

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

October 14, 1985

South Florida Water Management District
Post Office Box V, 3301 Gun Club Road
West Palm Beach, Florida 33402
Attention: Paul Millar

Dear Mr. Millar:

Permit No. 500877569, Palm Beach County
SFWMD C-51 Canal

The information required by Specific Condition 2 of the subject permit has been received and is adequate.

The enclosed drawings should be attached to and become a part of the permit.

Sincerely,

Michael D. Nagy
Environmental Supervisor
Standard Permitting Section

MDN/jk

cc: DER, WPB