JUNE 1992

CENTRAL AND SOUTHERN
FLORIDA PROJECT

FOR FLOOD CONTROL
AND OTHER PURPOSES

PART I, AGRICULTURAL AND CONSERVATION AREAS
SUPPLEMENT 54
GENERAL DESIGN MEMORANDUM AND
ENVIRONMENTAL IMPACT STATEMENT

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

US Army Corps
of Engineers
Jacksonville District

SYLLABUS

The Supplemental Appropriations Act of 1984 (Public Law 98-181) authorized the Secretary of the Army to conduct an experimental program for delivering water to the Everglades National Park to protect and enhance the Park, a national and international significant natural resource. The authorization permitted modification to the schedule of water deliveries from the Central and Southern Florida Project to the Park. However, direct compliance with the language and intent of PL 98-181 was not possible within the time frame mandated by the Act. A General Plan was prepared to develop a strategy for implementation of the authorization and was approved by the Assistant Secretary of the Army (Civil Works) on 28 February 1985. The General Plan recommended the preparation of a General Design Memorandum and an Environmental Impact Statement, addressing the modifications necessary to improve water deliveries to the Everglades National Park. In 1989, Congress passed the Everglades National Park Protection and Expansion Act (Public Law 101-229), authorizing the Secretary of the Army to modify the Central and Southern Florida Project upon completion of the Chief of Engineers report, in order to improve water deliveries to Everglades National Park and to take the necessary steps to restore the Park's natural hydrologic conditions and to enhance and restore its ecological values. This report addresses the Shark River Slough portion of water deliveries from the Central and Southern Florida Project to the Everglades National Park.

Under the direction of the Jacksonville District, U.S Army Corps of Engineers, the South Florida Water Management District developed a computer model to simulate the effects of different hydro-meteorologic conditions within the Central and Southern Florida Project boundaries. Many alternatives for improving the water deliveries to the Park were developed. Several of these alternatives are addressed in this report. They include the Base Condition (No Action Plan), a Flow Through Delivery Alternative, a Modified Minimum Water Delivery Alternative, a Rain-Driven Water Delivery Alternative, and a Modified Rain-Driven Water Delivery Alternative. Several other versions of the Rain-Driven Water Delivery Alternative were modeled and evaluated. Many alternative plans considered would provide flood mitigation measures for the residential area in the East Everglades.

The recommended plan was selected on the basis of expected environmental benefits derived from a modified water delivery schedule. A Rain-Driven Water Delivery Alternative was selected as the recommended plan. This alternative would replace the minimum delivery schedule authorized in Public Law 91-282 and would involve structural modifications to the Central and Southern Florida Project. The water control plan will be refined and further coordinated during the design and construction period. With the proposed project, water deliveries to the Everglades National Park would fluctuate based upon local hydro-meteorologic conditions.

The recommended plan involves the construction of three gated culvert structures (S-345A, B and C), three gated concrete headwall structures (S-349A, B, and C), and two spillway structures (S-355A and B). Also, the plan considers relocation of Structure 334, raising a portion of the Tamiami Trail (US 41), and degrading the existing Levee 67 Extension and filling the borrow canal. The recommended plan includes flood mitigation in the residential area through construction of two pump stations (S-356 and S-357) and a double levee and a canal around the western and northern reaches of the residential area. In addition, an airboat camp, and two Miccosukee Indian Camps will be raised to prevent flood damages from occurring due to implementation of the project.

In accordance with P.L. 101-229, the project's impact on the adjacent agricultural area of the East Everglades would be monitored. In addition this report recommends that monitoring of the endangered snail kite be conducted and funded by the Department of the Interior, U.S. Fish and Wildlife Service, through their normal budgetary process. Estimated cost of this monitoring program over a five year period is approximately $400,000. The total estimated cost of implementing the project is $81,330,000. This estimate includes construction of the proposed modifications, acquisition of lands for rights-of-way, and monitoring programs based on February 1991 price levels.

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

PERTINENT DATA

STRUCTURE 345 A,B, & C

Location	Levee 67A
Stations	625+00, 685+00, 745+00
Culverts:	
Type	CMP
Number	3
Diameter (in.)	72
Invert Elevation (ft.)	0.0
Type of Control	Slide Gate
Design Conditions:	
Discharge (cfs)	500
Headwater Elevation (ft.)	9.4
Tailwater Elevation (ft.)	7.9
Contract Price	$13,518,000

GATED CONCRETE HEADWALL STRUCTURES 349A, B, & C

Location	L-67A Borrow Canal
Type	Weir with Slide Gate
Design Discharge (cfs)	1,250
Control Gates:	
Number	4
Size - width by height (ft.)	12.0 X 10.0
Invert Elevation (ft.)	-4.0
Design Headwater Elevation (ft.)	7.2
Design Tailwater Elevation (ft.)	7.0
Contract Price	$4,227,000

NOTE: All elevations refer to National Geodetic Vertical Datum (mean sea level of 1929) unless otherwise indicated.

PERTINENT DATA - (continued)

SPILLWAY STRUCTURE 334 REPLACEMENT

Location	Levee 29 Borrow Canal
Station	20+00
Type	Gated Spillway with Ogee Weir
Design Discharge (cfs)	1,230
Control Gates:	
Number	1
Type	Vertical Lift
Size - width by height (ft.)	29.0 X 24.3
Crest Shape	Ogee
Crest Elevation (ft.)	-6.9
Apron Elevation (ft.)	-8.0
Design Headwater Elevation (ft.)	5.0
Design Tailwater Elevation (ft.)	4.7
Contract Price	$2,028,000

SPILLWAY STRUCTURES 355A & B

Location	Levee 29
Station	183+00, 307+00
Type	Gated Spillway with Ogee Weir
Design Discharge (cfs)	1,000
Control Gates:	
Number	2
Type	Vertical Lift
Size - width by height (ft.)	20.0 X 8.4
Crest Shape	Ogee
Crest Elevation (ft.)	1.8
Apron Elevation (ft.)	0.0
Design Headwater Elevation (ft.)	9.2
Design Tailwater Elevation (ft.)	8.9
Contract Price	$3,968,000

NOTE: All elevations refer to National Geodetic Vertical Datum (mean sea level of 1929) unless otherwise indicated.

PERTINENT DATA - (continued)

PUMPING STATION 356

Location	Levee 29 Borrow Canal
Station	15+00
Number of Pumps	Three
Pumping Station Capacity (cfs)	950
Average Annual Pumping (acre-feet)	72,000
Design Heads:	
Normal (ft.)	2.5 to 3.0
Design (ft.)	5.5
Intake Water Surface Elevations:	
Start Pumps (ft.)	5.5
Normal Drawdown (ft.)	5.0
Discharge Water Surface Elevations:	
SPF (ft.)	14.5
Maximum Pumping (ft.)	10.5
Normal Pumping (ft.)	7.5 to 8.0
Minimum Non-Pumping (ft.)	4.5
Total Contract Price	$18,376,000

PUMPING STATION 357

Location	Residential Canal
Pumping Station Capacity (cfs)	533
Average Annual Pumping (acre-feet)	54,000
Design Heads:	
Normal (ft.)	1.4 to 1.7
Design (ft.)	0.3
Intake Water Surface Elevations:	
Start Pumps (ft.)	5.7
Normal Drawdown (ft.)	5.7
Discharge Water Surface Elevations:	
SPF (ft.)	9.1
Maximum Pumping (ft.)	9.1
Normal Pumping (ft.)	6.7
Minimum Non-Pumping (ft.)	2.0
Total Contract Price	$5,752,000

Project Construction Cost	$73,942,000
Project Real Estate Cost	$ 6,913,000
Monitoring	$ 475,000
Total Project Cost	$81,330,000

NOTE: All elevations refer to National Geodetic Vertical Datum (mean sea level of 1929) unless otherwise indicated.

CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES

PART I

AGRICULTURAL AND CONSERVATION AREAS SUPPLEMENT 54 - GENERAL DESIGN MEMORANDUM

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

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CENTRAL AND SOUTHERN FLORIDA PROJECT
PREVIOUSLY ISSUED REPORTS

Seq.	Part*	Supplement	Title	Date
1	I	(Basic report)	Agricultural and conservation areas (with preliminary information on Lake Okeechobee and principal outlets)	7/10/51
2	I	1	Geology and soils	12/6/51
3	I	(1) 2	Agricultural area levees	12/29/51
4	I	3	Design Memo, Pumping Station 5A	1/28/52
5	V	2	Design Memo, Canal 4	2/22/52
6	V	3	Design Memo, Canal 9 and Structure 29	2/22/52
7	V	(2) 4	Hydrology and hydraulic design, Greater Miami area (preliminary draft)	2/23/52
8	V	(3) 1	Design Memo, Canal 11	2/27/52
9	I	6	Design Memo, Gates and operating machinery of control structures Structures 5A-E, 5A-W, and 5A-S	3/5/52
10	I	Addendum to 3	Design Memo, Pumping Station 5A	3/24/52
11	VI	(1) Section 1	Modified first phase plan	3/26/52
12	I	5	Test levee investigations	3/28/52
13	VI	(1) Section 3	Schedules, outlines, and costs for preparation of definite project report (advance copy)	5/8/52
14	VI	(1) Section 2	Construction schedule and cost estimates, authorized first phase (advance copy)	5/9/52
15	I	4	Structural design (works planned for construction through F.Y. 1953)	7/18/52
16	V	7	Design Memo (revised), Canal 11, Pumping Station 13, Control Structure 13A	8/8/52
17	V	8	Design Memo, Canals 12 and 13, Control Structures 33 and 36	10/31/52

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20	V	10	Design Memo, Vehicle-operated gate hoists	12/4/52
21	I	8	Design Memo, Development of plan of protection for agricultural area	2/6/53
22	I	7	Design Memo, Permeability investigations by well-pumping tests	2/16/53
23	VI	Section 4	Modified first phase plan, 1953	2/20/53
24	IV	1	Design Memo, Effectiveness of Lake Okeechobee outlets	3/12/53
25	V	5	Design Memo, Geology and soils	4/30/53
26	V	Section 5	Design Memo, Channel roughness	5/1/53
27	I	10	Design Memo, Pumping Station 6	5/27/53
28	I	9	Design Memo, Hydrology and hydraulic design of West Palm Beach Canal and related works (L-10 and L-12)	6/8/53
29	I	11	Design Memo, Hydrology and hydraulic design of West Palm Beach Canal and related works (L-18, L-19, L-20, and S-7)	6/17/53
30	I	13	Design Memo, Hydrology and hydraulic design of North New River Canal and related works (L-18, L-19, L-20, and S-7)	7/6/53
31	I	12	Design Memo, Hillsboro Canal (Levees 14 and 15)	7/15/53
32	I	15	Design Memo, Pumping Station 2	7/29/53
33	V	11	Design Memo, Hydrology and hydraulic design of Hollywood Canal (C-10)	7/31/53

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
34	I	14	Design Memo, Hydrology and hydraulic design of Miami Canal and related works (L-23, L-24, L-25, S-3, and S-8)	8/17/53
35	VI	Section 6	Design Memo, Rainfall-frequency estimates	9/4/53
36	IV	Supp. 2 Section 1	Hydrology and hydraulic design Design Memo, Storage level in Lake Okeechobee at beginning of critical hurricanes	10/13/53
37	I	16	Design Memo, West Palm Beach Canal (Levees 10 and 12)	10/15/53
38	I	17	Design Memo, Pumping Station 13	10/30/53
39	I	18	Design Memo, Revision of hydrology and hydraulic design of West Palm Beach, Hillsboro, North New River, and Miami Canals	11/16/53
40	I	19	Design Memo, North New River Canal (Levees 20, 19, and 18)	12/1/53
41	IV	Supp. 2 Section 2	Hydrology and hydraulic design Design Memo, Hurricane winds over Lake Okeechobee	12/31/53
42	IV	Supp. 2 Section 5	Hydrology and hydraulic design Design Memo, Lake-regulating facilities	1/12/54
43	IV	Supp. 2 (1) Section 3	Hydrology and hydraulic design Design Memo, Wind tides produced by hurricanes	1/21/54
44	IV	3	Design memo, Prototype tests of Lake Okeechobee type sector gates at Ortona Lock	1/28/54
45	I	30	Design Memo, Miami Canal (Levees 25, 24, and 23)	2/5/54
46	V	12	Design Memo, Hydrology and hydraulic design, canals in Greater Miami area (C-2 through C-9) (revised)	3/23/54

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
47	VI	Section 7	Design Memo, Interim report on evaluation of Manning's n in vegetated areas	4/2/54
48	IV	Supp. 2 (1) Section 4	Hydrology and hydraulic design Design Memo, Wave action coincident with wind tides	4/27/54
49	V	13	Design Memo, Water- and salinity-control structures in Greater Miami area	7/2/54
50	IV	Supp. 2 Section 6	Hydrology and hydraulic design Design Memo, Resistance of levees to wave erosion	8/13/54
51	V	14	Design Memo, Snapper Creek Canal (C-2) and Control Structure 22	10/1/54
52	IV	4	Design Memo, Effects of fresh-water discharges through St. Lucie Canal	10/27/54
53	I	21	Design Memo, Agricultural area levees, Levees 4 (east), 5, and 6	11/1/54
54	I	22	Design Memo, Agricultural area levees, Levees 2, 3, and 4 (west)	11/19/54
55	V	15	Design Memo, Snake Creek Canal extension (C-9, section 4)	12/15/54
56	VI	Section 8	Design Memo, Rainfall-excess evaluation	1/5/55
57	VI	(1) Section 10	Project authorizations	3/10/55
58	VI	Section 9	Design Memo, Regimen of runoff	3/16/55
59	IV	Supp. 2 Section 5A	Hydrology and hydraulic design Design Memo, additional lake-regulating facilities	3/28/55
60	V	16	Design Memo, Canal 17 and Control Structures 43 and 44	4/5/55
61	V	17	Design Memo, Snapper Creek Canal (C-2) navigation requirements	5/13/55

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
62	I	1) 23	Design Memo, Levee 39 and Spillway 10	6/20/55
63	II	1	Design Memo, Moore Haven-Newhall area (C-19, L-41, L-42, L-51, S-47B, S-47D, and S-81)	7/21/55
64	II	2	Design Memo, Hydrology and hydraulic design, Lake Istokpoga-Indian Prairie area (Canals 39A, 40, 41, and 41A, and Structures 66, 68, 70, 71, 72, 75, 82, 83, and 84)	11/28/55
65	I	24	Design Memo, Pumping Station 7	12/13/55
66	V	19	Design Memo, Canal 9, section 1	1/6/56
67	V	18	Design memo, Little River Canal (C-7)	1/17/56
68	II	4	General Design Memo, Hydrology and hydraulic design, Fisheating Creek area (C-22 and S-69)	4/24/56
69	II	3	Design Memo, Lake Ostokpoga-Indian Prairie area (Canals 39A, 40, and 41, and Structures 70, 71, 72, 75, and 82)	5/31/56
70	VI	Section 11	Design Memo, Meteorologic and water-level networks, parts I and V	6/19/56
71	IV	5	Special report on mullet migrations through St. Lucie Lock and Dam, 1955-56	6/20/56
72	IV	Supp. 2 Section 3 (Revised)	Hydrology and hydraulic design Design Memo, Wind tides produced by hurricanes	7/26/56
73	IV	Supp. 2 Section 4 (Revised)	Hydrology and hydraulic design Design Memo, Wave action coincident with wind tides	7/27/56
74	V	20	General and Detail Design Memo, Canal 18 and Control Structure 46	8/20/56
75	V	21	Detail Design Memo, Biscayne Canal (C-8) and Control Structure 28	9/24/56

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
76	II	5	General Design Memo, Kissimmee River Basin	10/8/56
77	VI	Section 12	Summary report, 1954 authorized works on which general design memo studies will not be completed by end of 1956	10/11/56
78	II	6	Design Memo, Plan of regulation for Lake Istokpoga	10/12/56
79	III	1	General Design Memo, St. Lucie County canals and control structures (Canals 23, 23A, 24, and 25, and Control Structures 48, 49, 50, 97, 98, and 99)	1/23/57
80	III	2	General Design Memo, Upper St. Johns River Basin	3/20/57
81	IV	6	General Design Memo, Caloosahatchee River and control structures (Canal 43 and Lock and Spillway Structures 77, 78, and 79)	4/24/57
82	I	26	Detail Design Memo, Pumping Station 8	5/27/57
83	V	(1) 22	Detail Design Memo, Canal 10 (Hollywood and Spur Canals)	9/26/57
84	I	25	General Design Memo, Plan of regulation for Conservation Area No. 1	11/29/57
85	II	7	Detail Design Memo, Canal 41A (Slough and Stub Canals) and Structures 66, 68, 83, and 84	1/22/58
86	I	27	General Design Memo, Plan of regulation for Conservation Area No. 2	2/28/58
87	IV	Supp. 2 (1) Section 7	Hydrology and hydraulic design Preliminary draft of General Design Memo, Combinations of hydrologic and hydraulic factors affecting height of levees	4/14/58
88	V	23	General and Detail Design Memo, Canal 14 and Control Structures 37A, 37B, and 38A	5/5/58

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
89	IV	8	Design Memo, General development plan, recreation, public use, and operation	5/6/58
90	I	23 (Revised)	Design Memo, Levee 39, Spillway 10, and interim modifications to Levees 7 and 40	July 1958
91	III	3	Detail Design Memo, Canals 23A and 24 (North Fork St. Lucie River and Diversion Canal) and Control Structure 49	9/19/58
92	II	8	Detail Design Memo, Automatic electric control system for Structures 66, 68, 70, 71, 72, 75, 82, 83, and 84, Lake Istokpoga-Indian Prairie area	10/30/58
93	II	5 Section 1	Kissimmee River Basin General Design Memo, Modification of Kissimmee River (C-38) for fish and wildlife	10/31/58
94	I	28	Detail Design Memo, Levee 38 (east), section 1	12/23/58
95	V	24	General Design Memo, Canals 15 and 16 and Control Structures 40, 41, and 42	12/31/58
96	IV	Supp. 2 Section 7	Hydrology and hydraulic design General Design Memo, Combinations of hydrologic and hydraulic factors affecting height of levees	2/25/59
97	V	25	General Design Memo, Canal 1 and Control Structure 21	2/27/59
98	V	26	Detail Design Memo, Cathodic Protection for Control Structures 22 & 29	3/10/59
99	V	27	General and Detail Design Memo, Canal 9 (Section 5) and Control Structure 30	4/20/59
100	IV	(5) 9	Detail Design Memo, Detail development plan, recreation facilities on Canals 43 and 44	5/14/59

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
101	IV	7	General and Detail Design Memo, Lake Okeechobee northwest shore levees (Levees 48, 49, and 50; Interceptor Dikes 59, 60, and 61; and Pumping Stations 127, 128, and 129, 130, 131, and 132)	5/29/59
102	I	29	Detail Design Memo, Levee 38, Section 2 (raising U.S. Highway 27 between Structures 11A and 11C)	7/28/59
103	I	30	General Design Memo, Levee 28 (Section 2)	9/15/59
104	IV	11	General Design Memo, Prevention of levee erosion by related works	9/24/59
105	I	31	Detail Design Memo, Levees 35B and 38 (Section 3); spoil islands--Levees 35B and 38 (Section 2); and Control Structure 38	10/13/59
106	IV	(6) 10	General Design Memo, Biological investigations of St. Lucie Estuary in connection with Lake Okeechobee discharges through St. Lucie Canal	10/15/59
107	V	29	General and Detail Design Memo, Modification of Control Structure 13A in Canal 11	10/22/59
108	V	28	Detail Design Memo, Canal 1 (Black Creek) and Control Structure 21	10/30/59
109	V	30	General Design Memo, Levee 31 and related works	11/6/59
110	III	4	Detail Design Memo, Canal 25 (Belcher Canal) and Control Structures 50, 98, and 99	12/10/59
111	V	22 (Revised)	Detail Design Memo, Canal 10 (Hollywood and Spur Canals)	5/20/60
112	I	33	General Design Memo, Conservation Area No. 3	6/22/60

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
113	VI	Section 13	Detail Design Memo, Hydraulic design of inlet structures	6/24/60
114	III	5	Detail Design Memo, Canal 23 and Control Structures 48 and 97	7/18/60
115	IV	13	Detail Design Memo, Pumping Stations 127, 129, and 131	9/7/60
116	IV	12	Detail Design Memo, Canal 43, Section 1 (Caloosahatchee River)	9/22/60
117	V	31	General and Detail Design Memo, Canal 1 and Control Structures 21, 148, and 149	9/29/60
118	I	34	Detail Design Memo, Levees 67A and 29, Section 3, and Control Structure 151	9/30/60
119	I	35	Detail Design Memo, Levee 29, Sections 1 and 2, and Control Structures 12A,	11/7/60
120	IV	14	Detail Design Memo, Herbert Hoover Dike, Levees D-1, D-2 (part), and D-3 (part)	5/26/61
121	I	36	General Design Memo, Hydrologic and meteorologic gaging programs, Conservation Area No. 3	5/31/61
122	II	9	Detail Design Memo, Canal 38, Section 1 (Kissimmee River), and Control Structure 65E	6/21/61
123	II	10	Detail Design Memo, Canals 31 and 35 (St. Cloud and South Port Canals) and Control Structures 59 and 61	6/23/61
124	IV	16	Detail Design Memo, Structure 79, lock and spillway on Canal 43	7/7/61
125	IV	15	Detail Design Memo, Canal 43, Section 2 (Caloosahatchee River)	8/4/61
126	V	32	Detail Design Memo, Levee 31 East, Section 1 (Old Cutler Road to Goulds Canal), and Control Structure 21B	1/5/62

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
127	V	33	Detail Design Memo, Canal 1, Section 3, and Control Structure 149	1/26/62
128	I	32	Detail Design Memo, Levee 28, Sections 2, 3, and 5	3/2/62
129	II	11	Detail Design Memorandum, Structure 65D	3/14/62
130	I	38	Detail Design Memorandum, Levee 68A	3/22/62
131	I	37	Detail Design Memorandum, Structures 24B, 31, and 150 (Conservation Area No. 3)	4/27/62
132	V	34	Detail Design Memorandum, Canals 15 and 16 and Control Structures 40 and 41	6/28/62
133	II	13	Detail Design Memorandum, Spillways and locks on Canal 38, Structures 65, 65A, 65B, and 65C	7/20/62
134	II	12	Detail Design Memorandum, Canal 38, Sections 2 and 3 (Kissimmee River)	8/17/62
135	IV	17	Detail Design Memorandum, Canal 43, Section 3 (Caloosahatchee River)	8/22/62
136	IV	18	Detail Design Memorandum, Herbert Hoover Dike, Levees D2 (Part), D9, and D4	9/18/62
137	II	14	Detail Design Memorandum, Canals 36 and 37 (Cypress-Hatchineha Canal and Hatchineha-Kissimmee Canal)	9/19/62
138	IV	20	Detail Design Memorandum, Structures 77 and 78 on Canal 43	11/15/62
139	II	15	Detail Design Memorandum, Canal 38, Sections 4, 5, and 6 (Kissimmee River)	2/11/63

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
140	IV	21	Detail Design Memorandum, Lake Okeechobee northeast shore area (L-47, L-62, L-63, L-64, L-65, S-133, S-134, S-135, S-152, S-153, S-154, tieback levees, inlet structures, etc.)	3/12/63
141	V	35	Detail Design Memo, Levee 31E, Section 2 (Goulds Canal to Florida City Canal), and Structures 20G and 21A	3/29/63
142	I	39	General Design Memo, Nine-Mile Canal Area (C-20, C-21, L-D1 borrow canal, S-4, S-47, S-169, S-170, railroad bridges, etc.)	3/29/63
143	VI	Section 14	Project authorizations to date	4/30/63
144	IV	19	Preliminary Master Plan, Caloosahatchee River	
145	V	36	General and Detail Design Memo, Cutler Drain Area (C-100, C-100A, C-100B, C-100C, S-118, S-119, S-120, S-121, S-122, and S-123)	7/23/63
146	I	40	Detail Design Memo, Levee 28 interceptor and feeder canals	8/23/63
147	IV	22	Detail Design Memo, Herbert Hoover Dike, Levee D3 (remainder)	9/5/63
148	V	37	General Design Memo, South Dade County	9/12/63
149	III	6	Detail Design Memo, Canals 54 and 56 (Sebastian and Poinsett Outlet Canals); Levee 73, Sec. 1 (Taylor Ck. portion of Jane Green Levee); and Structures 55, 96, 157, and 164	12/18/63
150	V	38	Detail Design Memo, Canal 111, Section 1, and Control Structure 18C	12/31/63
151	I	41	Detail Design Memo, Pumping Station 140	6/19/64

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
152	IV	23	Detail Design Memo, Canal 43, Sections 4 and 5 (Caloosahatchee River)	9/9/64
153	II	16	Detail Design Memo, Canals 33 and 34 (Alligator-Gentry Canal and Canoe Creek Canal)	9/28/64
154	V	39	Detail Design Memo, Canals 102 (Princeton Canal), 102(N), and Control Structures 165, 194, and 195	11/19/64
155	V	41	General and Detail Design Memo, Structures 124 and 125 (C-42 and related areas)	12/15/64
156	V	40	Detail Design Memo, Canals 103 (Mowry Canal), 103(N), and 103(S), and Control Structures 20F, 166, 167, 179, and 196	1/22/65
157	I	42	Detail Design Memo, Levee 38 (West), Section 1	2/11/65
158	IV	24	Detail Design Memo, Herbert Hoover Dike, Levee 47, and Control Structure 191	3/8/65
159	IV	25	Detail Design Memo, Pumping Stations 133 and 135	4/30/65
160	IV	19B (C-1)	Construction Design Memo, Olga Lock and Dam (S-79), Public-use facilities	6/8/65
161	V	42	Detail Design Memo, Levee 31 East, Section 3 (Florida City Canal to Card Sound Road) and Control Structures 20 and 20A	7/30/65
162	V	43	Detail Design Memo, Canal 111, Sections 2 and 3; Canal 111(E); and Control Structures 176, 177, and 178	8/31/65
163	II	17	Detail Design Memo, Canals 30 and 32 and Control Structures 57 and 58	11/30/65

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
164	V	44	Detail Design Memo, Levee 31(N) and Control Structure 173	1/31/66
165	II	18	Detail Design Memo, Canals 29, 29A, 29B, and Control Structure 62	7/29/66
166	IV	26	Detail Design Memo, Levees 64, 65, St. Lucie Canal north tieback levee, and Control Structure 153	10/28/66
167	V	45	Detail Design Memo, Canals 109 and 110, and Control Structure 18	12/15/66
168	V	46	General Design Memo, Canals 4, 5, and 6, and Control Structures 25, 25A, 25B, and 26	4/18/67
169	IV	28	Detail Design Memo, Lock Structure 193	6/5/67
170	IV	27	Detail Design Memo, Levees 62, 63(N), 63(S); Canal 59 and Control Structure 192	9/14/67
171	I	43	Detail Design Memo, Levee 13 (Cross Canal)	10/31/67
172	V	47	Detail Design Memo, Levee 31(W), Canal 113, and Control Structures 174 and 175	11/17/67
173	III	7	Detail Design Memo, Levee 73, Section 2, Canals 57 and 58, and Control Structures 161, 162, 163, and 221	2/28/68
174	I	44	Detail Design Memo, Pumping Station 4	4/22/68
175	V	48	Detail Design Memo, Canals 106, 107, and 108 and Control Structures 19 and 198	8/23/68
176	II	Supp. 5 Section 2	General Design Memo, Modification of Plan for Canals 46 and 46A and Structures 87, 87A, 87B, and 87C	4/11/69

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
177	I	45	Detail Design Memo, Canal 21 and Control Structure 169	6/6/69
178	V	45 (Revised)	Detail Design Memo, Canals 109 and 110, and Control Structures 18 and 199 (Revised)	10/14/69
179	IV	27 (Revised)	Detail Design Memo, Levees 62, 63(N) 63(S); Canal 59; and Control Structure 192 (Revised)	10/20/69
180	IV	29	Detail Design Memo, Seaboard Coast Line Railroad Bridge B-142 Over Levee 63(N) Borrow Canal	8/10/70
181	III	9	Detail Design Memo, Levee 72, Control Structure 160, Culverts 1 thru 6	8/18/70
182	I	47	Detail Design Memo, Canal 20, Levees D1 and D3 Connecting Canal and Control Structures 47, 233, 234, and 235	12/30/70
183	V	50	Detail Design Memo, Coastal Areas South of St. Lucie Canal - Control Structure 25 in Miami Canal (C-6)	11/26/71
184	IV	30	Detail Design Memo, Lake Okeechobee and Outlets - St. Lucie Canal Tieback Levees	1/13/72
185	I	46	General and Detail Design Memo, Pumping Station 236	2/28/72
186	V	49	General and Detail Design Memo, Canals 12N and 13, Control Structures 224 and 237	4/4/72
187	V	51	General and Detail Design Memo, West Palm Beach Canal and Related Areas with Detail Design Appendix on Pumping Station 319	Jun 72
188	I	47 (Revised)	Detail Design Memo, Canal 20	6/12/72

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
189	I	49	General and Detail Design Memo, Modification of Levees 7, 35B, and 38, Section 2 (U.S. Highway 27 - Between Structures 11A and 11C) and Deletion of Canal 302	8/31/72
190	V	54	Detail Design Memo, Canal 51 and Control Structures 155 and 155A	Nov 72
191	V	53	Detail Design Memo, Control Structures 25 and 25A in Comfort Canal (C-5) and 25B in Tamiami Canal (C-4)	Nov 72
192	IV	31	General and Detail Design Memo, Port Mayaca Lock (S-308B) and Spillway (S-308C)	Nov 72
193	V	52	General Design Memorandum Conveyance Canals to Everglades National Park and South Dade County with Detail Design Appendix on Pumping Station 331 and Enlargement of Reaches of Levee 31(N) Borrow Canal, C-1 and C-103	Jun 73
194	V	55	Detail Design Memo, Levee 29, Section 3, Borrow Canal Enlargement, Pumping Station 332, and Control Structures 194(Mod), 333, 334, 335, 336, and 338	Aug 74
195	V	56	Detail Design Memo, Levee 30, Borrow Canal Enlargement, and Control Structure 32A and 337	Mar 76
196	IV	52	General and Detail Design Memo, Lock Structure 310 (S-310)	May 76
197	I	48	General Design Memorandum Hendry County Area with Detail Design Appendix on Structure 239 and Canals 139 and 139 South	Feb 77
198	I	53	General and Detail Design Memorandum on Structures 339 and 340	Sep 77

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
199	I	51	General and Detail Design Memorandum on L-18 and L-19 (North New River Canal), and L-24 and L-25 (Miami Canal) Hump Removal	3/78
200	V	52 (Addendum 1)	General and Detail Design Memorandum, Enlargement of Canal 304 and Culvert Structure 151, Addendum 1	6/78
201	V	57	Buttonwood Canal Improvements and Related Works, Everglades National Park, Structure 341	7/79
202	V	51 (Addendum 1)	Detail Design Memorandum Canal 51 - East End and Control Structure 155	12/81
203	II	19	General Design Memorandum Nicodemus Slough Area	1/82
204	IV	33	General Design Memorandum Spillway Structures 351 (HGS-4)	6/84
205	III	11	General Design Memorandum, St. Lucie County Water Supply Element, C-131, Enlargement C-28 Portion, PS-214, S-115, S-116, S-117, S-118, PS-307, PS-313, S-112, and S-348	6/84
206	III	2 (Addendum 3)	General Design Memorandum Upper St. Johns River Basin with Draft Environmental Impact Statement	7/84
207	V	54	Detail Design Memorandum Canal 51-West End, Control Structure 155A and Pumping Station 319	7/85
208	IV	34	Design Memorandum Spillway Structure 351 (HGS-4)	6/85
209	IV	35	General Design Memorandum Spillway Structure 352 (HGS-5)	8/85
210	IV	37	Detail Design Memorandum Spillway Structure 352 (HGS-5)	5/86

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
211	III	12	Detail Design Memorandum Structure 96B and Tieback Levee	7/86
212	IV	36	General Design Memorandum Spillway Structure 354 (HGS-3)	12/86
213	III	13	Detail Design Memorandum Structure 161A and Tieback Levee Structure 255, Levee 74N (Part) and Levee 74E	3/87
214	IV	38	Detail Design Memorandum Spillway Structure 354 (HGS-3)	4/87
215	III	14	Detail Design Memorandum S-252A, S-252B and S-252C Levee 78 and Levee 79	8/87
216	III	15	Detail Design Memorandum Structure 96C and 96D	10/88
217	III	15	Detail Design Memorandum Structure 96C and 96D	Revised 2/89
218	III	16	Detail Design Memorandum S-250A, S-250B, S-250C, S-251 and S-254, Levee 74W, L-77 and L-74N (Part)	3/87
219	V	54 (Addendum 2) (Revised)	Detail Design Memorandum Canal 51 - West End, Control Structures 155A and 360, Pumping Station 319 and Levee 85	9/89
220	II	20	General Design Memorandum Shingle Creek, C-120A, C-120B, S-353 and Environmental Structures ES-1, ES-2, and ES-3	9/89
221	III	17	Detail Design Memorandum Levee 75 (Section 1)	10/89

PREVIOUSLY ISSUED REPORTS--Continued

Seq.	Part*	Supplement	Title	Date
222	III	18	Detail Design Memorandum Levee 74 N. Part, Levee 75 Remainder, and Structure 256	3/91
223	III	19	General Design Memorandum Master Plan - Recreation Upper St. Johns	10/91

NOTES: *Parts designated as follows:

I--Agricultural and conservation areas
II--Kissimmee River Basin and related areas
III--Upper St. Johns River Basin and related areas
IV--Lake Okeechobee and outlets
V--Coastal areas south of St. Lucie Canal
VI--General studies and reports

(1) Superseded by later studies
(2) Superseded by Part V, Supp. 12
(3) Superseded by Part V, Supps. 7 and 9
(4) Superseded by Part V, Supp. 6, dated September 8, 1952
(5) Superseded by Detail Design Memo No. 1, Okeechobee Waterway, Fla., dated December 17, 1959
(6) Superseded by consultant's report, dated October 15, 1959

CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES

PART I

AGRICULTURAL AND CONSERVATION AREAS SUPPLEMENT 54 - GENERAL DESIGN MEMORANDUM

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

A. INTRODUCTION

1. Authorization.

a. PL 98-181, 30 November 1983. The Supplemental Appropriations Act, 1984 (Public Law 98-181) authorized the Secretary of the Army to conduct an experimental program for delivering water to Everglades National Park. This authorization allows modification of the current schedule of water deliveries from the Central and Southern Florida Project. The pertinent section of the Act is quoted:

> *Sec. 1302. The Secretary of the Army is authorized, for a period of two years beginning with enactment of this Act with the concurrence of the Director of the National Park Service and the South Florida Water Management District, to modify the schedule for delivery of water from the Central and Southern Florida project to the Everglades National Park required by section 2 of the River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970 (Public Law 91-282) and to conduct an experimental program for the delivery of water to the Everglades National Park from such project for the purpose of determining an improved schedule for such delivery.*
>
> *The Secretary of the Army is further authorized to acquire such interest in lands currently in agriculture production which are adversely affected by any modification of schedule for water delivery to Everglades National Park under the preceding paragraph. The Secretary shall acquire any interest in land at the fair market value of such interest based on conditions existing after the construction of the project described in the preceding paragraph of this section and before any modification of such delivery schedule. The Secretary is also authorized to construct necessary flood protection measures for protection of homes in the area affected by any modification of such delivery schedule, at an estimated cost of $10,000,000.*

b. General Plan for Implementation of an Improved Water Delivery System to Everglades National Park, Florida, January 1985. Direct compliance with the language and intent of PL 98-181 was not possible within the timeframe provided. The General Plan was prepared to develop a strategy for implementation of the authorization and was approved by the Assistant Secretary of the Army (Civil Works) on 28 February 1985. It recommended the following:

(1) Preparation of a General Design Memorandum (GDM) and an Environmental Impact Statement (EIS) addressing modifications necessary to improve water deliveries to Everglades National Park (ENP); and

(2) Extension of the two-year time limit specified in PL 98-181 based upon a written agreement between the Jacksonville District, ENP, and South Florida Water Management District (SFWMD).

c. PL 99-190, 19 December 1985 (Section 115). This law amended PL 98-181 to extend the Experimental Program until 1 January 1989.

d. PL 100-676, 17 November 1988 (Section 40). Section 1302 of PL 98-181 was amended by this law, The Water Resources Development Act of 1988, and extended the Experimental Program until 1 January 1992.

e. PL 101-229, 13 December 1989 (Section 104). The Everglades National Park Protection and Expansion Act authorized the Secretary of the Army, upon completion of this GDM, to modify the Central and Southern Florida project to improve water deliveries to ENP and to take steps to restore the Park's natural hydrological conditions.

Section 104 (b)-(h) also authorized and directed the Secretary to construct a flood protection system for the residential area in the East Everglades and adjacent agricultural areas, if the Secretary determines those areas will be adversely affected by operation of the project. To protect agricultural areas, the Secretary must find that there is a substantial reduction in the areas' present economic utility which is attributable solely to the project modification or the residential flood protection system. The Secretary was directed to review the operation of the modified project within 18 months, and periodically thereafter, to determine whether agricultural areas are being adversely affected and to protect the areas if necessary. However, any preventive measure shall be implemented in a manner that presents the least prospect of harm to the natural resources of ENP. The Secretary was also directed to coordinate the construction program with the Secretary of the Interior to permit the Park's expansion (land acquisition) program to proceed concurrently.

f. PL 102-104, 17 August 1991 (Section 107). This law amended section 1302 of PL 98-181 to continue the Experimental Program until the modifications to the Central and Southern Florida project authorized under section 104 of Public Law 101-229 are completed and implemented.

2. Purpose and Scope. This report addresses the Shark River Slough (SRS) portion of water deliveries from the Central and Southern Florida (C&SF) Project to Everglades National Park. Water deliveries to Taylor Slough and to the eastern panhandle area of the Park are being addressed in other studies. Also, land acquisition for ENP expansion is being addressed under the guidelines contained in PL 101-229. The purposes of this report are as follows:

a. Develop a plan for an improved water delivery system for ENP;

b. provide designs and cost estimates for all structural and operational modifications necessary for implementation of the improved delivery system;

c. identify the most cost effective alternative means of mitigating potential adverse impacts to developed areas in the East Everglades, either flood protection or acquisition of real estate interests;

d. describe potential environmental benefits to be obtained as a result of hydrologic changes produced by the improved water delivery system.

3. Local Cooperation. A Local Cooperation Agreement (LCA) will be required between the U.S. Army Corps of Engineers and the local sponsor. The LCA is a legally binding document between the Federal government and the local sponsor identifying the sponsor duties and obligations for this project. However, in accordance with current Federal policy, the LCA can not be executed until construction funds for the project have been appropriated. The South Florida Water Management District (SFWMD) is the project sponsor and represents local interest.

Since Section 104(a)(3) of the Everglades National Park Protection and Expansion Act authorizes construction of the project based on "the environmental benefits to be derived by the Everglades ecosystem in general and by the park in particular", all first costs shall be 100 percent Federal including the value of lands, easements, rights of way, and relocations provided for construction of the project. Operation and Maintenance (O&M), Repair, Replacement and Rehabilitation (RR&R) costs shall be not more than 75 percent Federal. These costs are consistent with staff agreements previously reached between the Office of Management and Budget and the Assistant Secretary of the Army (Civil Works).

Acquisition of lands for Everglades National Park expansion shall be in accordance with PL 101-229 and cost shared between the Department of the Interior and the State of Florida.

The specific requirements of local cooperation will be prescribed by the LCA and will comply with the following general guidelines:

a. Contribute a minimum of 25 percent of total costs needed to operate and maintain, repair, replace, and rehabilitate the project works involved to mitigate the increased risk of flooding in the residential area including the levee and canal system, the pumping stations, and the structural works and modifications in the Water Conservation Area No. 3 and adjacent canals.

b. Hold and save the United States free from damages due to the construction or subsequent operation and maintenance of the project, except any damages due to the fault or negligence of the United States or its contractors;

c. Prevent encroachment on the flood-carrying capacity of the project including the culvert system under the U.S. 41 road; and,

d. Maintain and operate the works after completion in accordance with regulations prescribed by the Secretary of the Army, except for the water control structures and outlets in Water Conservation Area No. 3, which will be maintained and operated by the Corps of Engineers.

4. References.

a. Dade County Planning Department. East Everglades Resources Planning Project - Residential Land Use, November 1978.

b. Dade County Planning Department. East Everglades Resources Planning Project - Agricultural Use, November 1978.

c. Dade County Planning Department. East Everglades - Resources Planning Project, Proposed Management for the East Everglades, October 1980.

d. Dade County Planning Department. Dade County Agricultural Land Use Planning Project, presented to Everglades National Park - East Everglades Resources Planning and Management Committee, June 18, 1984.

e. U.S. Army Corps of Engineers. Draft Feasibility Report and Draft Environmental Impact Statement on Central and Southern Florida Project - Shark River Slough, September 1982.

f. Everglades National Park/East Everglades Resource Planning and Management Implementation Plan. Adopted by the Everglades National Park/East Everglades Planning and Management Committee, April 18, 1985.

g. U.S. Geological Survey. Hydrologic Effects of Water Control and Management of Southeastern Florida, Report of Investigation No. 60, 1972.

h. U.S. Army Corps of Engineers. General Design Memorandum on Conveyance Canals to Everglades National Park - South Dade County, Part V Supplement 52, Central and Southern Florida Project for Flood Control and Other Purposes, June 27, 1973.

i. South Florida Water Management District. Evaluation Report, A Thirty Day Field Experiment of Water Deliveries to Northeast Shark River Slough, July 1984.

j. South Florida Water Management District. A Wet Season Field Test of Experimental Water Deliveries to Northeast Shark River Slough, Technical Publication 85-3, September 1985.

k. South Florida Water Management District. South Florida Water Management Model Documentation Report, Technical Publication 84-3, February 1984.

l. South Florida Water Management District. South Florida Regional Routing Model, Technical Publication 86-3, June 1986.

m. South Florida Water Management District. Supplemental Water Use in the Everglades Agricultural Area, Technical Publication 74-4, June 1974.

n. U.S. Army Corps of Engineers. General Design Memorandum, Agricultural and Conservation Areas - Conservation Area No. 3, Part I, Supplement 33, Central and Southern Florida Project for Flood Control and Other Purposes, June 22, 1960.

o. U.S. Army Corps of Engineers. General and Detailed Design Memorandum, Structure 339 and 340, Part I, Supplement 53, Central and Southern Florida Project for Flood Control and Other Purposes, September 1977.

p. Letters of Agreement between U.S. Army Corps of Engineers, South Florida Water Management District and Everglades National Park. Letter of Agreement with Addendum 1, July 24, 1985. Addendum 2, December 28, 1987. Addendum 3, August 24, 1988. Addendum 4, April 21, 1989.

B. PROBLEM IDENTIFICATION

5. Study Area. The focus of this investigation is water deliveries to the Everglades National Park. A large area outside the Park's boundaries affects flows available to the Park due to the sensitive hydrologic interconnection of all components of the Everglades. Conversely, water deliveries to the Park can affect water supply available for south Dade County, as well as water conditions in Water Conservation Area Number 3 (WCA No. 3) a component of the Central and Southern Florida Project (C&SF). In addition to the Everglades National Park, a major portion of the remaining undeveloped Everglades is located in the C&SF Project's Water Conservation Areas.

The study area for this investigation is shown on Figure 1. It includes the Everglades National Park, East Everglades, and the two parts of Water Conservation Area Number 3 - WCA No. 3A on the west and WCA No. 3B on the east. The area is located in Broward and Dade Counties, west and southwest of the Miami metropolitan east. It is bounded on the west by the Big Cypress National Preserve; on the north by the Everglades Agricultural Area (EAA) and Water Conservation Area Number 2 (WCA No. 2); and on the east by Levee 30 (L-30), Levee 31 North (L-31N), and Levee 31 West (L-31W).

The historic Shark River Slough was the principal pathway of water draining slowly southward from Lake Okeechobee to tidewater. Water flowed from Lake Okeechobee, and then:

* Through what is now WCA No. 3A; then,

* Through what is now WCA No. 3B; then,

* Through the area now called Northeast Shark River Slough (NESRS), which is bordered by Levee 67 Extension (L-67 Ext.) on the west; Levee 29 (L-29), which is the southern component of WCA No. 3, and is adjacent and parallel to U.S. Route 41, (the Tamiami Trail) on the north; and L-31N on the east; and,

* Through the portion of Everglades National Park immediately south of L-29, the southern boundary of WCA No. 3A (sometimes called the "Chimney" of Everglades National Park).

Under natural conditions, the eastern boundary of the Everglades extended eastward to the coastal ridge, which is well beyond the study area boundary. However, these areas have been developed and extensive urban and agricultural development now exists in the historic peripheral Everglades. Restoration of these areas is beyond the scope of this study. The Shark River Slough is a very broad (as much as 40 miles, depending upon season), shallow, natural drainage way at a slightly lower elevation than the surrounding Everglades.

The area known as East Everglades includes the NESRS and a developed area along the slough's eastern boundary. It is bounded on the north by L-29, on the east by L-31N, on the south by Everglades National Park, and on the west by the Park and L-67 Ext.

6. Plan Formulation Process. This part of the report describes the evolution of alternative plans considered for improving water deliveries to Everglades National Park. As background, it describes the relationships between hydrologic and ecologic conditions in the Everglades, historic conditions, the existing base condition, and the expected future condition of the Everglades without any project to improve water deliveries. Next, the report explains the study's chronological formulation of alternative plans. The process of formulating alternative plans proceeded through a series of planning iterations, or steps (called "phases" in this part of the report), during which certain conditions led to the development of a set of alternative plans. These plans were evaluated, and rejected or selected for further improvement and analysis. Figure 2 displays the general plan formulation phases that occurred during this study. Mitigation and monitoring requirements were generally applicable to all plans, and are discussed following the explanations of plan formulation phases.

7. Everglades Hydrological-Ecological Relationships. Water is crucial to the Everglades ecosystem and has a direct effect on the plants and animals of its wetlands. The location, timing, duration, and depth of inundation patterns, along with other factors, determine the distribution and composition of the vegetative and wildlife communities in the ecosystem. The hydrologic regime also influences nutrients, chemical composition and other components of water quality within the ecosystem. Table 1 illustrates some of the annually recurring cycles of the Everglades' hydrology and ecology. Additional information on the interrelationships between the Everglades' hydrology and ecological conditions is in Appendix C of the Environmental Impact Statement.

8. Climate. The climate of the area is categorized as subtropical since occasional frosts do occur. Local rainfall is the most important factor affecting conditions in the Everglades. There is a distinct variation in annual rainfall (53.2 inches average annual rainfall) during the year between the dry season months, from November through May (averaging 17.4 inches of rain), and the wet season months, from June through October (averaging 35.8 inches of rain). There is also a great deal of variation in annual rainfall. At Homestead, near the eastern edge of Everglades National Park, annual rainfall has ranged from a high of 94 inches in 1947 to a low of 37 inches in 1971.

9. Hydrology. The major characteristics of South Florida hydrology are: (1) local rainfall, (2) evapotranspiration, (3) canals and water control structures, (4) flat topography, and (5) the highly permeable Biscayne Aquifer near the land surface along a thirty to forty mile wide coastal strip. Water that is introduced from either direct rainfall or canals is rapidly removed by evapotranspiration, seepage into the aquifer, or canal and overland surface drainage to the Atlantic Ocean, Florida Bay, or the Gulf of Mexico. Water that is introduced at a rate that exceeds that of removal tends to inundate a large area to relatively shallow depths. Additional information about the region's hydrologic characteristics is included in Appendix D and the Environmental Impact Statement.

10. Periphyton, the small water organisms that live on submerged surfaces, are a conspicuous and ecologically important element of the Everglades ecosystem. As primary producers, periphyton represent a major component of the marsh food chain. Periphyton provide both food and habitat for a wide variety of grazing invertebrates and forage fish, which are in turn consumed by other fish, wading birds, and reptiles. Laboratory studies have shown that periphyton may be an important food source for Everglades crayfish. Inasmuch as periphyton represent the base of the Everglades food web, major changes in species composition and biomass of the primary producer community ultimately influence the species composition and biomass of higher trophic level organisms.

The formation of thick periphyton mats aids in the survival of aquatic organisms during drought by preventing the desiccation of their eggs and larvae. As water levels rise, aquatic insects and forage fish rapidly repopulate the reflooded marsh. A large portion of the total primary production of the lower Everglades appears to be derived from periphyton algal mats.

11. Vegetation. The region's vegetative associations are critically dependent on the subtle interplay of minuscule changes in elevation (on the order of inches), salinity, and humus accumulation. Eight different vegetative associations are located in the area: sawgrass Everglades, mangrove forest, salt marsh, cypress forest, pine forest, mixed West Indian hardwood hammock forest, bayhead, and Cape Sable saw palmetto salt prairie.

The vegetative communities most strongly affected by hydroperiod change are wetlands, particularly sawgrass marshes, spike rush flats, and prairies and the more hydric forest communities, such as bayheads, bayhead-hammocks and cypress formations. In general, the most visible results of reducing the hydroperiod on marshes and prairies, particularly in the East Everglades, are the rapid colonization by a variety of native and exotic broad-leaved tree species with an attendant reduction in the vigor and relative abundances of hydric species, and a decline in the vigor and stature of the community dominants. The consequences of a reduced hydroperiod on the hydric forest communities are also marked, but more subtle than those in marshes and prairies.

While exotic plant species invade a variety of natural vegetation communities, their spread in wetlands is attributed primarily to the decline in vigor and health of the natural communities, mostly associated with reductions in water depths. Excess nutrients and frequent fires, especially during the dry season, also promote the spread of exotics.

12. Fisheries. Freshwater fish densities are highest in marshes with seasonally fluctuating water depths and extended hydroperiods. In marshes with short hydroperiods of less than eleven months, fish populations decline. Fish provide a major part of the diet of many of the Everglades' other animal inhabitants. Although extended hydroperiods are conducive to increases in freshwater fish population, natural drawdowns concentrate fish populations in the marsh making them available for wading birds to feed. Garfish are the alligator's staple food, while dense populations of sunfish and various small

fish are essential to the success of large heron rookeries. Mullet, saltwater catfish, and other fish species support osprey, brown pelicans, cormorants, and great white herons.

13. Wading Birds. The wood stork is an indicator of the general wading bird population in the interior southern Everglades. Because the stork's specialized feeding technique requires high concentrations of small fish in shallow water, it is especially sensitive to events that alter water levels and thus influence the timing of nesting and availability of fish. From peaks in the 1930's, local nesting populations of wading birds declined slowly through the 1950's and more rapidly during the 1960's, and then crashed in the years since the 1970's. The current level for most species is estimated to be roughly ten to twenty percent of the populations that existed in Everglades National Park when it was authorized in 1934.

14. Alligators modify wetland habitats by creating ponds, dens, trails and nest mounds. Alligator ponds serve as dry season refuges for fishes and aquatic invertebrates which, in turn, are prey for wood storks and other wading birds. Alligators are relatively abundant in the Everglades because of their longevity and adaptability. While a natural source of mortality in alligator populations is egg mortality caused by flooding, egg loss can become excessive due to large or rapid water discharges from water management activities. Alligators are so successful and have recovered from previous low numbers so rapidly that they can withstand higher egg mortality for many years before the population would decrease to the point where changes in the Everglades ecosystem could be noticed. There would be fewer gator holes and reduced fish and bird habitat, with a delay of three to ten years before population decline could be detected. Alligators' maintenance needs include:

* Persistent ponds or sloughs to ensure that larger forage organisms can survive drought events.

* Adequate extent of flooded habitat to produce forage.

* Relatively dependable seasonal flooding and drying progressions, especially rising water levels in late spring and early summer, to ensure nesting success.

15. Fire has been an important factor in Everglades ecology, primarily associated with lightning strikes during the wet season. By 1934, the development of canals, levees, roads, farm fields and other artificial fire breaks interrupted the run of natural wet season fires, thus reducing the natural fire frequency and consequently allowing succession to occur at the expense of the prevailing natural communities. In addition, increased fires, both accidental and deliberate by man's actions in the dry season, when fires are not naturally common, add severe stress to native species. Dry season fires kill individuals of species that are otherwise naturally fire-dependent, consume the upper layer of organic sediments, alter the critical surface topography, and release excess nutrients. Dry season fires also promote exotic species.

16. Historic Conditions. The Everglades was originally a broad, shallow, freshwater wetland flowing imperceptibly from the southern shore of Lake Okeechobee southward about 100 miles to the coastal glades of Florida Bay. It was about forty miles wide with ground elevations that sloped from between elevation 15 to 17 ft., NGVD, near Lake Okeechobee, to sea level at Florida Bay. Water levels fluctuated widely on an annual and seasonal basis. During wet years, Lake Okeechobee would overflow its southern shore and spill water into the Everglades. Water flowed southward in a thin sheet through the historic course of Shark River Slough to Florida Bay; and eastward to tidewater through transverse glades in the coastal ridge. During dry years, surface water flow through the Everglades was very limited, and very little of the area would be inundated. However, some believe groundwater gradients continued to contribute some level of base flow and helped reduce coastal salt water intrusion.

While there is no quantitative information about the area's ecological resources prior to the twentieth century, numerous descriptive accounts tell of canoe passages up the Shark River and through Everglades marshes; of coastal rookeries where the green of mangrove trees were snow white with nesting "curlews" (probably white ibis); and of tarpon, snook and bass fishing in the lower rivers. Alligator populations in the region are estimated to have been extremely high before European settlement, with more than one million animals estimated to have been living south of the current Tamiami Trail based on the number of "gator holes" present in the region. Figure 3 shows the extent of the Everglades as it was surveyed in the mid-1850's.

Anecdotal accounts of the early Everglades' explorers suggest that peripheral wetlands were much more extensive, and that the central Shark River Slough held some surface water throughout most dry seasons. Under these conditions, it is likely that as the peripheral areas dried, large areas of edge habitat made fish concentrations available to wading birds. As the drying edges moved toward the center of the slough, new feeding areas were made available over a prolonged period during the nesting season. It may be that, unlike today, the central valley of Shark River Slough rarely dried completely except during extreme droughts, thus, providing a reserve from which fishes could recolonize peripheral marshes after each dry season. Prolonged flooding of the central slough would have provided the conditions for forming the peat sediments found there, while the increased hydroperiod in peripheral areas would have produced higher total fish and macroinvertebrate populations. Figure 4 shows the historic path of Shark River Slough through the study area.

Human habitation in the Everglades dates back to about 500 A.D. The Tequesta Indians inhabited much of southeastern Florida, including the Everglades, until the seventeenth century, when diseases brought by Spanish explorers severely reduced their population. The Seminole and Miccosukee Indians inhabited the area during the eighteenth and nineteenth centuries, but were driven from the Everglades into southwest Florida as a result of the Seminole Wars in the mid-1800's.

The potential for economic development in the favorable conditions of south Florida led to numerous major construction projects for the purposes of first draining and then controlling flows through the historic Everglades. Table 2

summarizes major events and trends that have affected the Everglades over the past hundred years. The first developmental work began in 1881 when Hamilton Disston constructed canals to lower water levels in the Kissimmee River Basin upstream of Lake Okeechobee. By 1927, six major drainage canals had been constructed by the local Everglades Drainage District. These canals were intended to drain water from Lake Okeechobee and the Everglades to tidewater for the purpose of making Everglades muckland available for agricultural production. The Tamiami Trail (U.S. Route 41) was also constructed in the 1920's. The roadway, which connected the Atlantic and Gulf coasts, essentially formed a levee with intermittent culverts to permit southward flow of surface waters. By 1930, the natural flow patterns through the Everglades had been significantly altered.

The effects of this initial development on the region's ecological conditions are summarized in Table 3 and described in detail in Appendix C of the Environmental Impact Statement. In general, the loss of natural wetlands due to drainage led to significant declines in wading bird populations, such as the wood stork, native fishes, and alligators, and exotic plant species spread throughout the region. Seasonal fire patterns were changed, with canals, levees and other artificial fire breaks interrupting the run of natural wet season fires and man's accidental and deliberate actions increasing the frequency of dry season fires.

In 1934, Congress authorized the Everglades National Park to preserve the unique plant and animal species of the area in an essentially primitive, natural condition. The Park, located on the southern tip of Florida, was finally created in 1947. With about 1.4 million acres, it remains the third largest park in the United States. Big Cypress National Preserve, located northwest of the Park, was established in 1974 to provide an ecological buffer zone and protect the Park's water supply.

Extreme droughts, followed by disastrous floods in 1926, 1928 and 1947, led to Congressional authorization of the Central and Southern Florida Project in 1948. The project's purposes are flood control, prevention of saltwater intrusion, water supply to Everglades National Park, municipal and industrial water supply, and preservation of fish and wildlife resources. Construction was started in the early 1950's. With the completion of the project's Water Conservation Areas Numbers 3A and 3B (WCA No. 3A and WCA No. 3B), natural flows into Everglades National Park became subject to control by regulation schedule. Figure 5 shows the general location of flows throughout the south Florida area as a cumulative result of all projects undertaken since the late 1800's.

The U.S. Geological Survey began making flow measurements across Tamiami Trail into the Everglades and Big Cypress in 1940. Flow data are compiled for three flow sections; 40-mile Bend to L-67A is the section through which the S-12 structures discharge flows into the western half of the Shark River Slough; L-67A to L-30 is the section that discharges into the East Everglades; and 40-mile Bend to Monroe is the section that discharges into Big Cypress. The Big Cypress flow section represents flows that have not been significantly affected by man. It can be used as a baseline from which impacts resulting from structural alterations on the other two flow sections can be measured.

Figure 6 shows a discharge hydrograph for the three flow sections across Tamiami Trail from 1940 through 1968. Figure 7 presents the cumulative discharges across the flow sections for the same period with the time scale adjusted so the Big Cypress flow section discharge plots as a straight line.

In this way, changes in flow caused by structural alterations can be seen as changes in slope for the other two flow ways. Figures 6 and 7 were taken from United States Geological Survey (USGS) Report of Investigations No. 60, "Hydrologic Effects of Water Control Management of Southeastern Florida" by Leach, Klein, and Hampton, 1972.

Following severe impacts in the Park from droughts in the early 1960's, Congress passed the River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Acts of 1970 (Public Law 91-282), which established a minimum water delivery schedule to protect the Park's ecological resources. While it was designed to guarantee a minimum annual water supply in specified monthly quantities, the effect of the delivery schedule created new problems. The release of water to the Park from WCA No. 3A, through the four S-12 water control structures, was still constrained in part by the needs of other consumers and the requirement for releasing excess water during high water periods. Moreover, releases from WCA No. 3A into the Park were directed to the west side of the main historic flow-way - the Shark River Slough - which altered hydropatterns in the Park. Only the west half of the slough was within Everglades National Park. At that time, the U.S. Department of the Interior, the Federal agency responsible for the Park, believed that the Park would benefit from as much water as possible. Many of the Central and Southern Florida Project's features were designed based on this philosophy. Releases from WCA No. 3A into the west side of Shark River Slough, combined with the effects of L-67 (completed in 1967) which prevents releases to ENP from spreading eastward, resulted in an abbreviated hydroperiod and lower water levels in the adjacent NESRS. Consequently, it has been possible for the relatively high ground along the extreme eastern edge of the area to be developed for residential and agricultural purposes, while most of the East Everglades, which is in private ownerships, remains as wetlands.

The changed flow patterns that resulted from the full range of development in southern Florida caused the ecological conditions in the Park to further deteriorate, as summarized in Table 3 and described in detail in Appendix C of the Environmental Impact Statement. Table 2 summarizes the Everglades Development. Occasionally, excess water releases from WCA No. 3A for flood control purposes caused water stages in the Park to unnaturally increase during the normal dry season, disrupting nesting and feeding patterns of alligators and wading birds. Park records show that wood storks had five out of nine successful nesting years prior to 1962, but only four successful nesting years in the twenty-two years after 1962. All other wading birds showed a steady decline in nesting populations. Rapid changes in water releases have destroyed alligator nests through inundation, and fish populations declined due to a reduced hydroperiod.

C. BASE CONDITION

17. C&SF Project. Essentially all water deliveries to Everglades National Park other than direct rainfall are provided by the C&SF project. The overall project is shown on Plate 1. Also, Plate 1 shows the project's features in the vicinity of the study area. In total, the project's three Water Conservation Areas, WCA Nos. 1, 2 and 3, include the largest remaining portion of undeveloped Everglades in existence. WCA No. 3 is the largest and southernmost of these areas, with a total size of about 915 square miles. It is divided into WCA No. 3A on the west (760 square miles) and WCA No. 3B on the east (155 square miles) by L-67A and C. The project's features and operational procedures are described in detail elsewhere in the General Design Memorandum. The primary project features of concern for the purposes of this study are:

* WCA Nos. 3A and 3B;

* L-29, which encloses WCA Nos. 3A and 3B on the south, and controls southward sheet flow;

* The four S-12 structures, labeled A, B, C and D, which permit point flow releases from WCA No. 3A into Shark River Slough and Everglades National Park;

* L-67A borrow canal which collects overland sheetflow through WCA No. 3A and conveys this water rapidly southward where it ponds immediately north of L-29;

* L-67A and C, which separate WCA No. 3A from WCA No. 3B, and prevent sheet flow from moving from WCA No. 3A to 3B;

* L-31N, which separates the East Everglades from the more heavily developed areas east of the levee, and prevents sheet flow from moving eastward into these developed areas; and,

* L-67 Extension, divides Shark River Slough below L-29, and prevents releases from the S-12 structures from fanning out into the NESRS immediately south of WCA No. 3B.

In order of contributing magnitude, the three major sources of surface water in the study area during a normal meteorological year are: (1) in-situ rainfall, (2) regulated discharge of water from WCA No. 3A, through the S-12 structures, into Everglades National Park, and (3) seepage from WCA No. 3B through L-29 into the Tamiami Canal and, thence, through culverts into NESRS. An average annual rainfall of about 58 inches contributes about 2.5 million acre-feet of water to the study area. Water delivered through the S-12 structures over the period 1971-1981 represents about another fourteen percent of the volume from annual rainfall. Seepage from WCA No. 3B into NESRS for the same period represents about another two percent of the rainfall input.

The operation of the project to deliver water to Everglades National Park is governed by the requirements of PL 91-282, which was enacted following droughts in the early 1960's. This law established a minimum schedule of water volume to be delivered to the Park through three delivery points: Shark River Slough and two locations east of the study area. The minimum delivery to Shark River Slough was set at 260,000 acre-feet annually, which must be distributed in accordance with a monthly schedule of minimum water releases. In times of water shortage, the law allows deliveries to be cut back to a volume representing 16.5 percent of the total volumes released from the C&SF Project. Tables 4 and 5 show the required monthly minimum deliveries prescribed by PL 91-282 for the entire project and for Shark River Slough, respectively. Tables 6 and 7 show the required monthly minimum delivery to Taylor Slough and the Eastern Panhandle, respectively.

Actual water volumes delivered from the C&SF Project through Shark River Slough to the Park are determined based on Federal regulations, the physical capabilities of the system, and management decisions of the Corps, the Park, and the South Florida Water Management District. The principle governing factor in deciding the volume of water to discharge is the stage (height) of water in WCA No. 3A. Operating practice has been to provide monthly deliveries as close to delivery schedule as is possible without a deficit whenever water in WCA No. 3A is below regulation schedule. This is done to maintain sufficient storage in WCA No. 3A both to ensure that water is available for subsequent Park deliveries, and to satisfy other purposes of the project, such as storage for wildlife conservation and aquifer recharge.

When water released from WCA No. 3A is not sufficient to keep WCA No. 3A from exceeding its schedule stage, additional "flood" releases are made to lower the stage in WCA No. 3A. The S-12 structures are the main means of discharging flood waters. Minor flood releases can also be made, under certain conditions, westward into Big Cypress and eastward, via S-151, into WCA No. 3B. Figure 5 shows the general path of water releases through the study area.

Average annual discharge of water into Everglades National Park through the S-12 structures for the period of January 1971 through December 1987 was about 392,000 acre-feet, which was 51 percent above the 260,000 annual minimum delivery schedule. The extra water was almost entirely a result of flood releases from WCA No. 3A that were made in order to keep the stage within the regulation schedule. Most of the excess was delivered during the months of July through October, which is during the normal wet season. The greatest release as a percentage of the delivery schedule occurred during the period March through August. Data for the delivery schedule, regulatory releases and average releases by month for the 1970's are included in the Environmental Impact Statement, Table 4.

18. Water Quality. The quality of water delivered to Everglades National Park is frequently influenced by urban and agricultural activities elsewhere in the watershed. Of particular concern are floodwaters released from the Everglades Agricultural Area (EAA) into WCA No. 3A. The Everglades is a nutrient poor system and the introduction of nutrients, particularly phosphorus, from the agricultural areas is thought to have significantly

affected sawgrass and wet prairie habitat in the water conservation areas through which EAA discharges pass en route to Everglades National Park. Large acreage in WCA Nos. 1, 2, and 3 have been converted to cattail, an otherwise uncommon plant in the Everglades, as a result of nutrient increases. Lower in the WCA system, particularly in the southern portion of WCA No. 3A and in the Shark River Slough, there is yet relatively little conversion to cattail. This is thought to be the result of the removal of nutrients by vegetation upstream. Water that reaches the S-12 release structures in L-29 through sheet flow over WCA No. 3A shows phosphorus levels of less than ten parts per billion total phosphorus, whereas water delivered through the L-67A canal frequently exceeds thirty parts per billion total phosphorus. However, total phosphorus concentrations vary seasonally with annual rainfall amounts and are often higher following periods of severe drought. Average seems to vary between eight and fifteen parts per billion.

19. Periphyton. Loss of historic inflows has reduced the aquatic productivity of Everglades National Park by reducing the areal coverage of the periphyton community. Reduced flows also appear to have affected periphyton species composition. Studies have shown that the taxonomic composition of Park periphyton was significantly correlated with hydroperiod length and soil percent organic matter, which are both largely regulated by water management activities. Shortened hydroperiods and low percentages of soil organic matter favored the development of blue-green periphyton over other groups of algae, such as diatoms and green algae. Other studies have shown that both fish and invertebrate grazers selected against blue-greens, favoring diatoms or green algae as a preferred food source.

20. Vegetation. The Everglades National Park region contains eight different vegetative associations as previously described. Wetland communities occupy most of the East Everglades. The most common community in the East Everglades is sawgrass marsh (about 37% of the area), with the combined mesic grass communities, such as muhly grass and beard grass, rank second (about 30% of the area). In the NESRS, some ecological modifications to the natural plant communities have occurred because of the changed hydroperiod and fire patterns.

Since the 1930's, several exotic plant species have become established in parts of Everglades National Park and adjacent areas. Aquatic weeds are found, but have not yet posed a major problem, in the Park. Three woody exotics pose threats to the Park: Casuarina, Melaleuca, and Schinus. While exotics invade a variety of natural vegetation communities, their spread in wetlands is attributed primarily to the decline in vigor and health of the natural communities, mostly associated with reductions in water depths and hydroperiods. The invasion of Melaleuca has been a problem in NESRS.

21. Birds. About 300 species of birds have been identified in Everglades National Park. Southern Florida's location makes it a migratory crossroads for West Indian and Central and South American birds; numerous North American species are residents. Many of this continent's species of wading birds, shorebirds, and water fowl are represented here at some time of the year. Many of them are nesting residents, including some which seldom range farther north and others which have disappeared from areas where they once occurred.

Between the late 1970's and 1987, wood storks and other wading birds in the Park experienced perhaps the most rapid rate of decline of any decade in south Florida history. The mean annual breeding population of storks was only 374 pairs in the 1980's. Fewer than 2,000 pairs of great egrets and 1,500 pairs of snowy egrets have nested in mainland colonies of the Park and WCA No. 3 in most years since 1980. Only 2,500 pairs of white ibis in 1986, and 5,000 pairs in 1987, nested in the entire region.

Since the early 1960's, the distribution of water deliveries has affected wading birds mainly in two ways. First, the concentration of southward water flow in the Everglades into the northern portion of Everglades National Park resulted in a longer hydroperiod in the wetlands that received the flow, and in long-delayed and incomplete dry season drawdowns. Often, food was never sufficiently concentrated and available to support major wading bird nesting attempts. Or, as was commonly the case with wood storks, food became available only late in the dry season, and nesting was delayed so that it could not be completed before the beginning of the summer rains. Second, the already reduced foraging area available to wading birds was sharply diminished by eliminating flow to NESRS. This probably resulted in a substantial decline in aquatic productivity and loss of a significant portion of the available early dry season feeding habitat. Loss of these early season foraging areas meant that storks must shift their feeding to the more deeply flooded central Shark River Slough. Thus, it abruptly became the drier years, when water was low enough in the central slough to support early winter foraging by waders, that became the successful nesting years. Because of additional reductions of productive foraging area, however, nesting attempts have also become increasingly subject to disruption by dry season rainfall events that interrupt the seasonal drawdown. Figure 8 depicts the change in conditions for the bird population.

22. Fisheries. The Park's waters support a large variety of fish in both freshwater and saltwater habitats. Fish populations in the Park's portion of Shark River Slough are seasonally and annually variable, being affected by both ambient and antecedent water conditions. Density and diversity are highest during extended high-water periods without severe dry-down. In contrast, high water conditions without seasonal fluctuations do not make fishes available to wading birds. Fish populations in NESRS are about thirty percent less dense than those in the slough marshes within the Park. These lower densities are attributed to the long-term reduction of hydroperiods in NESRS marshes since the early 1960's.

23. Alligators. The current alligator population has recovered from an estimated eighty to ninety percent reduction in numbers since the late 1800's. However, the current population is recovering into very changed conditions in Shark River Slough. NESRS, which once received more water, now receives less; and the western slough inside Everglades National Park where alligators are concentrated, now receives more water than it did before minimum delivery schedules were imposed in 1971. Moreover, in the western and central portions of the slough, especially south of the L-67 extension canal, the problem of water delivery has been compounded by the discharge of too much water, often too quickly, during the alligator nesting season.

The current problem for the alligator population is tied to the pattern of water discharges into the Shark River Slough. Ideal conditions for alligators fall within the range of natural conditions expected for the Everglades during any given series of years:

(1) Moderate, progressive reduction in surface water during the dry season, culminating in lowest levels in late May, coincides with increasing densities of adults in anticipation of mating; and,

(2) Positive correlation between early wet season (late June) surface water levels and later maximum water levels (late August) results in nests being built at heights that minimize nest flooding and consequent egg mortality. Figure 9 depicts the changes in conditions for the alligator population.

Wildlife populations move freely between the Park and the East Everglades. Wildlife habitats are continuous between these two areas, and both provide feeding and nesting areas for mobile wildlife such as colonial wading birds, alligators, deer, and certain endangered species.

24. Endangered Species. The study area is included in the range of sixteen animal species that are listed as threatened or endangered under the Endangered Species Act. The Environmental Impact Statement includes additional information about these species.

25. Fire. In the drier conditions of the last four decades, destructive fires, primarily of the incendiary dry season type, have destroyed or damaged numerous tree islands, pinelands, and wetlands with organic soils in Everglades National Park. Many of these fires have entered the Park from East Everglades, where unusually dry conditions have permitted fires to spread rapidly and broadly. These fires, along with unfavorable hydrologic conditions, have weakened individuals of native plant species, permitting the establishment of exotic species, particularly *Schinus* on tree islands and *Melaleuca* in marshes and islands.

26. Development in East Everglades. Human development in the study area is limited to the East Everglades, which includes about 6,900 acres primarily in residential development, about 5,600 acres in agricultural development, and about 107,600 acres in the southern portion of NESRS in private and public ownership (SFWMD currently owns 35,000 acres) that is essentially undeveloped. There are approximately 8,300 private ownerships in the NESRS portion of the East Everglades.

27. Residential Development. Residential land lies primarily in a narrow tract parallel with and extending several miles west of L-31N. As of 1978, there were 139 permanent homes, including 60 mobile homes, in the area serving as residents for farmers and commuters to Miami. In addition, there were residences along both sides of the Tamiami Trail occupied primarily by American Indians of the Miccosukee Tribe. The total resident population of the entire East Everglades is estimated to be 430 individuals.

Much of the East Everglades is flood prone under current conditions. Recognizing the wetland nature of much of the area, zoning restrictions have been imposed by Dade County to curtail further residential development. Current zoning limits development density to no more than one unit per forty acres. Parts of the residential area are developed more densely than the current zoning would allow because many houses in the area were constructed when the zoning limit was one unit per five acres. Department of the Army permits must be obtained for construction of house pads required in the area.

28. Commercial Development. Commercial enterprises in the East Everglades lie along the east side and consist of several nurseries, a kennel, a fruit packing house, and a rabbit farm. On the Tamiami Trail, there is a commercial airboat operation, a gas station, a restaurant, and souvenir shops.

29. Agricultural Development. About 3,000 acres of land are under agricultural cultivation within and adjacent to the East Everglades residential area paralleling L-31N. In the order of total acreage planted, the primary crops are: winter vegetables (tomatoes, squash), tropical vegetables, tropical fruits (Persian limes, lemon-limes, mangoes), and ornamentals. The Soil Conservation Service of the U.S. Department of Agriculture considers the area to be unique farmland because it is in a frost-free climate permitting the production of winter crops.

30. Recreation. Everglades National Park is the primary recreational resource in the study area. Average annual Park attendance is about one million visitors. The Park contains numerous sites and interpretive trails for observing the natural environment. At Flamingo, which is adjacent to Flamingo Bay at the southern tip of mainland Florida, there are facilities for boating, fishing and camping. Chekika State Park, located on Grossman Hammock in the East Everglades, has camping, picnicking, and interpretive nature facilities. The Kendall Gliderport near the State Park provides opportunities for soaring and skydiving. Most of NESRS is used for recreational activities such as airboating, hunting, and, along the canals, fishing.

31. Cultural Resources. The study area contains several cultural resource sites. Historical use of the Everglades by aboriginal peoples is evidenced primarily by black earth middens and burial grounds, both usually located on high ground such as tree islands. The middens were typically seasonal camps used by small bands of people in foraging for wildlife and growing food crops. The Shark River Slough contains many such middens or burial grounds located on the characteristic tree islands. The site of Fort Henry, the Army supply depot in the Everglades during the Seminole Wars, is located in the East Everglades. Approximately ten sites in the East Everglades are now included on the State of Florida Archives Master Site File and many more lie within the Park.

32. Northwest Wellfield. The Northwest Wellfield is a municipal and agricultural water supply wellfield for south Dade County, located east of WCA No. 3B between the Tamiami Trail and the Miami Canal. Industrial development in the wellfield's cone of influence has required that pumpage be reduced to avoid water quality problems. Canal improvements currently under construction will enable the wellfield to be used to its capacity without water quality problems, and are assumed to be in place in alternative plan evaluations.

D. FUTURE WITHOUT PROJECT CONDITION

33. General. The C&SF Project will continue to be in place, and project water deliveries to Everglades National Park will continue in accordance with the schedule specified in PL 91-282. Operation of the minimum delivery schedule will involve the transfer of water from WCA No. 3A into Shark River Slough and Everglades National Park through the S-12 structures. Figure 4 illustrates the water delivery patterns of the future without condition.

34. Water Quality. Agricultural and urban areas in the northern Everglades are expected to continue to influence water quality in the study area and Everglades National Park if no further action is taken. Major ion, color and iron concentrations should continue to increase until they reach equilibrium primarily by the physical processes of dispersion and dilution from rainfall and overland sheet flow. If inflow from the Everglades Agricultural Area is kept at the present level or greater, increases in nitrogen and phosphorus concentrations at the northern points of inflow to the Park should increase. Also, depending on the volume and rate of flow from the pumping stations, sediments and bottom material contaminated with metals and pesticides should migrate slowly southward through the WCA canals.

The South Florida Water Management District is developing a Surface Water Improvement Management (SWIM) Plan to resolve water quality issues in the Everglades Agricultural Areas and the WCA's. The Plan proposes action to substantially reduce nutrient loading to the WCA's and Everglades National Park within five years of implementation. If the goals of the SWIM Plan are accomplished, the threat posed by phosphorus loading from the agricultural areas would be eliminated, thereby, assuring very high quality water for the lower portion of WCA No. 3 and Everglades National Park.

35. Periphyton and Vegetation. Water quality changes would, in turn, affect vegetation in the study area. Nutrient impacts on Park vegetation and periphyton communities have been relatively minor to date due to uptake by the WCA marshes upstream of the Park. However, the WCA sawgrass and cattail communities appear to have a limited uptake capacity for phosphorus and nitrogen. Once this capacity is reached, nutrients are recycled rather than stored, and are ultimately passed downstream. The effects of such increases in nutrient supply include: reduced dissolved oxygen concentrations in surface water, a periphyton community shift toward lower abundance of diatoms and desmids, and a progressive macrophyte community shift from sawgrass to cattail.

Continuation of authorized water management practices will also affect vegetation. Prolonged flooding will decrease swamp hardwoods and sawgrass density along L-67 and in southern WCA No. 3A. Elsewhere, the effects of shortened hydroperiods and lower water depths will also continue. Woody species will be established in graminoid wetlands. Muhly grass will increase in abundance with a decrease in sawgrass density. Increased fire frequency will continue to burn tree islands and decrease sawgrass abundance. Primary production and formation of peat and marl soils will be depressed in these areas. Exotic plant species, particularly Melaleuca, will become an increasing problem in Everglades National Park.

36. Fisheries. Fish populations are expected to continue to be adversely affected by unseasonable water releases, regular and extensive drawdowns, and unnatural hydroperiod alterations. Severe drought, exacerbated by water supply demands, have dried much of the central Shark River Slough marshes several times in the past decade. This has seriously reduced some fish populations, especially sunfishes, which are important prey for wood storks. Several years of reflooding of these central marshes are needed before the fish community can be restored to its pre-drought condition. Prolonged flooding of marshes, as in WCA No. 3A, results in fish community changes. The absence of seasonal fluctuations sharply decreases fish availability to wading birds. Shortening the hydroperiod of NESRS marshes appears to alter marsh food webs, reduce aquatic animal biomass, and produce inferior foraging habitat for wading birds. Unseasonal water releases into the Park in the past twenty years dispersed concentrations of fishes, probably leading to the disruption of nesting by wading birds. These conditions would be expected to continue without any change in the current water delivery system.

37. Birds. Breeding populations of wood storks and other waders in Everglades National Park will continue to decline. Populations of storks, white ibis, snowy egrets and great egrets have dropped at a dramatic pace since the 1970's. There is no sign that this trend will reverse without some significant change in water management practices. The wood stork, especially, may disappear as a breeding bird in the Park within the next five to twenty years under current water management practices.

Cape sable seaside sparrow populations may increase if muhly grass habitat increases are not offset by a proportionate increase in invasion by Melaleuca. Snail kites would make less frequent use of the Park as declining water levels decreased populations of the apple snail or made them less accessible to the kite. Other species may eventually stabilize at population levels capable of being supported by mangrove-estuarine habitats alone.

38. Alligators. Under the present water delivery system, the alligator population will be restricted in range to the western portion of Shark River Slough and restricted in available habitat, and the quality of this habitat will be low due to the potential for rapid or large water discharge into the Park. Alligator numbers will expand more slowly, and there is a higher potential for density dependent factors to affect reproductive rates within the restricted range. Refuges for aquatic life and sources of food for wading birds will suffer along with the alligators.

39. Fires. With the increasing human density in southern Florida, and its growing demands on water and activities in undeveloped areas, man-caused fires will become more frequent and the intensity and damage of fires will increase. This will destroy some plant communities, and increase the establishment and dominance of exotic plant species.

40. Everglades National Park. The Everglades National Park Protection and Expansion Act of 1989 authorizes the Secretary of the U.S. Department of the Interior to acquire about 107,600 acres as an addition to the Park. This acreage is located in the East Everglades and includes NESRS; maps of the area are in Appendix A of the Environmental Impact Statement. Addition of this area to the Park will further help preserve the fringes of the remaining Everglades and restore a vital portion of the historic Shark River Slough to the Park. For the purposes of this study, the Park expansion is expected to be completed, and is independent of any modifications that may be recommended for the Central and Southern Florida Project. However, until the land acquisition for park expansion is complete, water deliveries to NESRS would be restricted and would be similar in magnitude to those under the ongoing experimental program.

41. Development in East Everglades. No further development will take place in the East Everglades wetlands (NESRS) because these lands will be acquired by the National Parks Service and incorporated into Everglades National Park in accordance with the Everglades National Park Protection and Expansion Act.

42. West Dade Wellfield. Dade County is planning the addition of a major new wellfield in the western portion of the county. A site has not been selected. Due to the uncertainty of the wellfield's future location, it is not included in the without condition. The recommended plan also was modeled assuming that a West Dade Wellfield was not in place. A future evaluation will be conducted when a definite site, capacity, and pumping conservation strategy are identified. Location of the wellfield is not dependent on features presented in the recommended plan. However, its maximum capacity could be project dependent since the Everglades National Park Protection and Expansion Act imposes some limitations on the operation of the future West Dade Wellfield.

E. OBJECTIVES AND CONSTRAINTS

43. Basis for Objective. In the without project condition, the Central and Southern Florida Project will continue to consist of its existing structures, and will be operated in accordance with the procedures developed pursuant to PL 91-282. This law prescribed minimum water deliveries to ENP prior to enactment of Section 107 of Public Law 102-104 which continues the experimental program until the modifications authorized under Section 104 of PL 101-229 are completed. The project and its method of operation will continue to produce hydrological conditions that contribute to the ecological deterioration of Everglades National Park. Such changes are described above, and would include:

* Habitat changes, including a gradual transition from long hydroperiod wetlands, such as sawgrass, to drier wetland communities, such as muhly grass prairie.

* Wildlife species changes, including some population decreases (fish, wading birds), and some population increases (deer, Cape Sable seaside sparrow). Alligator populations will probably peak at a lower level.

* Changes in other ecological factors, such as increased fire threats and the invasion of nonnative exotic plants.

The unique ecological value of the Everglades has been long recognized both nationally and internationally. In recognition of its unique natural and cultural properties, the United Nations designated Everglades National Park as both an International Biosphere Reserve and a World Heritage Site in 1979, making it one of only eight areas in the world to receive this dual recognition. Formal national recognition dates back to 1934 when Congress authorized the creation of the Park to preserve for posterity the Everglades' unique ecology.

The decline in the Park's ecological value has also been a longstanding concern. In March 1983, the Superintendent of Everglades National Park issued a request, referred to as the Seven Point Plan, for actions to protect the Park. The Seven Point Plan was prompted primarily by two conditions. First, there was a significant deterioration in the Park's ecological conditions following the extremely wet period that coincided with the normally 1982-1983 dry season. These conditions followed many previous years of dry season floods. Second, in response to concerns and requirements by the Florida Department of Environmental Regulation regarding eutrophication of Lake Okeechobee, the South Florida Water Management District implemented in early 1983 the Interim Action Plan (IAP). The IAP called for the maximum possible volume of water from the Everglades Agricultural Area to be pumped into the WCA's before pumping into Lake Okeechobee was implemented. The IAP was adopted as the long-term plan in 1986, and is now referred to as the Lake Okeechobee Operating Permit (LOOP). It was felt that implementation of the IAP would increase the frequency of future unseasonal water releases to ENP. See Plate 2 for the Lake Okeechobee regulation schedule.

A summary of the Seven Point Plan, and Corps responses to its recommended actions, is as follows:

1. Fill in the L-28 Canal and remove substantial segments of the L-28 Levee. The Corps constructed a series of plugs, culverts and gaps as emergency measures in 1984 to fulfill this request.

2. Fill in the L-67 Extension Canal and remove the L-67 Levee. The Corps also constructed plugs in this canal in 1984; removal of the levee is addressed in this study.

3. Restore WCA No. 3B to the Everglades system. The Corps conducted this on an experimental basis as described later in this report. Structural modifications to accomplish this request are addressed in this study.

4. Distribute WCA No. 3A water deliveries along the full length of the Tamiami Trail between L-28 and L-30. The Corps is also doing this on an experimental basis as described later in this report; and structural modifications to accomplish this request are addressed in this report.

5. Establish a water quality monitoring program. The Corps now monitors the quality of delivery water in accordance with an agreement with Everglades National Park and the South Florida Water Management District.

6. Defer implementation of new drainage districts. The State of Florida has responsibility for local drainage districts; and the Corps has no authority over this request.

7. Field test a new schedule for delivery of water to the Park. The Corps has tested a series of new delivery schedules over the past several years as described later in this report.

More recently, in the Everglades National Park Protection and Expansion Act of 1989, the President and the Congress recognized:

> "The Everglades National Park is a nationally and internationally significant resource and the park has been adversely affected and continues to be adversely affected by external factors which have altered the ecosystem including the natural hydrologic conditions within the park."
>
> "Wildlife resources and their associated habitats have been adversely impacted by the alteration of natural hydrologic conditions within the park, which has contributed to an overall decline in fishery resources and a 90 percent population loss of wading birds."
>
> "The existing boundary of Everglades National Park excludes the contiguous lands and waters of the Northeast Shark River Slough that are vital to long-term protection of the park and restoration of natural hydrologic conditions within the park."

"Incorporation of the Northeast Shark River Slough and the East Everglades within the park will limit further losses suffered by the park due to habitat destruction outside the present park boundaries and will preserve valuable ecological resources for use and enjoyment by future generations."

In accordance with these findings, the Act's purposes, "are to (1) increase the level of protection of the outstanding natural values of Everglades National Park and to enhance and restore the ecological values, natural hydrologic conditions, and public enjoyment of such area by adding the area commonly known as the Northeast Shark River Slough and the East Everglades to Everglades National Park; and (2) assure that the park is managed in order to maintain the natural abundance, diversity, and ecological integrity of native plants and animals, as well as the behavior of native animals, as part of their ecosystem".

To fulfill these purposes, the Act authorizes the Department of the Interior to acquire and administer about 107,600 acres of the Shark River Slough and East Everglades as a part of Everglades National Park. In addition, the Act authorizes the Secretary of the Army, in consultation with the Secretary of the Interior, to, "construct modifications to the Central and Southern Florida Project to improve water deliveries into the park and shall, to the extent practicable, take steps to restore the natural hydrological conditions within the park".

44. Objectives. The future without project condition will lead to further deterioration of unique and outstanding ecological resources of the Everglades that are recognized and valued throughout the world. Therefore, based on the direction provided in the Everglades National Park Protection and Expansion Act of 1989, the goal is to restore natural hydrologic conditions in the Park. Meeting this goal will lead to improvements in the abundance, diversity and ecological integrity of native plants and animals in the Park.

Natural hydrologic conditions can be measured in three dimensions: timing, location, and volume of water. An assessment of changes in these dimensions will indicate the degree to which the objective - to restore natural hydrologic conditions - can be met. This assessment is qualified by several considerations. First, in terms of timing and volume, the natural hydrologic condition does not mean a static historic condition. Rather, the natural hydrologic condition fluctuates, as it did historically, in response to local rainfall, upstream water contributions, and other natural factors in the Everglades hydrologic system. Restoring the natural hydrologic condition will result in wide natural variations in water availability from year to year, including the extremes of natural floods and droughts, as well as natural variations in depth and volume within the normal annual wet and dry seasons. Second, in terms of location, the natural hydrologic condition should reflect the historic condition of water flow through Shark River Slough, including flow in what is now WCA Nos. 3A and 3B, NESRS, and the Park. Third, the direction to "restore the natural hydrologic conditions within the park" is

qualified by the charge to do so "to the extent practicable". This requires evaluation of a wide variety of environmental, economic and social factors to determine what is practicable, but permits investigation of a range of solutions that will meet the objective to varying degrees.

To meet the goal condition, the following objectives of timing, location, and volume were developed:

a. Timing - According to the PL 91-282 operating criteria, water deliveries to the Park are provided at rates close to the minimum monthly requirements under most conditions (see Table 5 for monthly minimum deliveries to Shark River Slough). This provides a uniform water delivery schedule with little variation unless there are extreme floods or drought conditions in WCA No. 3A. Furthermore, under normal operating conditions, water deliveries do not fluctuate in response to rainfall patterns. In addition, if water levels in WCA No. 3A rise above regulation schedule, it becomes necessary to increase the water delivery from the minimum monthly rate up to the maximum rate possible, resulting in an abrupt, unseasonal "flood". Changing the water delivery schedule so that it fluctuates in consonance with local meteorologic conditions, including providing for long term and annual variation in hydrologic conditions in the Everglades would meet the timing conditions of the objective. The recession to dry season water flows should be moderate and progressive without large and sudden changes.

b. Location - The historic center of the Shark River Slough passed through what is now WCA No. 3A, then into WCA No. 3B, then crossing the East Everglades and into the Park near the middle of L-67 Extension. Under historic natural conditions, all four of these areas responded similarly to hydrologic events. However, under the current operating criteria, there are no inflows into WCA No. 3B or the East Everglades except for direct rainfall, seepage, and, occasionally, floods. Water deliveries to Shark River Slough in the Park are provided through the four S-12 structures located west of the center of the historic flow-way, as shown on Figure 4. The L-67 Extension prevents these discharges from spreading into the center of the historic flow-way in NESRS. Additionally, a significant portion of water discharged at the S-12 structures is conveyed down the L-67 Extension borrow canal, and under wet conditions, water levels can be substantially higher west of L-67 Extension than those to the east as a result. Restoration of WCA No. 3B as a functioning component of the Everglades hydrologic system and restoration of water deliveries to NESRS, the center of the historic Shark River Slough, would meet the location condition of the objective. Figure 4 also illustrates the location dimension of the objective.

c. Volume - Table 5 shows minimum monthly water deliveries to Shark River Slough. Water volumes are closely related to the location and stage of water at any given time. Since the East edge of the Everglades has been shifted to the west, the size of the Everglades is now much smaller, and, therefore, the volume of flows through the area may need to be adjusted under some conditions to minimize the effects of too much water.

45. Problems and Constraints. During the course of formulating alternative plans to meet the study's objective, several problems and constraints were identified by concerned interests. These constraints limited the types of measures that were acceptable, led to new measures that would resolve problems caused by a plan, or resulted in some measures being rejected. The constraints are explained in the context in which they occurred in the following section of this report, and included:

Problems

* Landowners in the East Everglades were concerned about their property rights regarding flooding of their homes, property and access roads without compensation and provision of flood protection, if needed, for existing development.

* Agricultural interests were similarly concerned about potential flooding effects of East Everglades farmlands.

* The Miccosukee Indian Tribe wanted to be assured that any project would not cause flooding to their villages or require relocation. They also favored wetlands restoration that would enable them to maintain their traditional lifestyle.

Constraints

* The U.S. Fish and Wildlife Service was concerned about the effects of changed water conditions in WCA No. 3 on the snail kite, an endangered species.

* The original project purposes of the Central and Southern Florida Project, including flood control and water supply, must be maintained.

F. ALTERNATIVES

46. The Process of formulating alternative plans proceeded through a series of iterative steps, or phases, during which ever-evolving reasons led to the development of a set of alternative plans. The major alternatives considered were the Flow-Through Water Deliveries Alternative (FT), Rain-Driven (RD), Restricted Rain-Driven (RRD), Basic Rain-Driven (BRD), Modified Rain-Driven (MRD), and Modified Minimum Delivery (MMD) alternatives. The following diagram depicts the alternative plans considered in the phases of plan formulation.

Phase 1	FT					
Phase 2		RD	RRD			
Phase 3				BRD	MRD	
Phase 4					MRD	MMD

Under the alternatives evaluated, several other modifications were required as a result of the increased water levels in NESRS. These measures included mitigation for induced flood damages in the East Everglades, mitigation for induced damages in the Osceola and Tiger Tail Indian Camps, modifications to Tamiami Trail, relocation of S-334, and monitoring effects in the East Everglades agricultural area. These modifications are covered in detail in the following section.

47. PHASE 1: Flow-Through Alternative (FT).

a. Reason for the Phase. A flooding event which occurred in 1983 set the direction for the development of the various alternative plans evaluated for Everglades National Park. Heavy rains had occurred during the wet season and continued into the dry season. This resulted in unseasonal flooding in ENP. The water levels in WCA No. 3A were expected to be above regulation stage, because the resulting accumulation of flood waters in Lake Okeechobee required releases during the normal dry season. The Corps and representatives of the ENP discussed increasing water releases from WCA No. 3A over the minimums outlined by PL 91-282 to avoid a large damaging release. However, ENP asked the Corps to hold off on the increased releases. As the water levels in WCA No. 3A increased, it became necessary to open the S-12 structures to release the accumulated flood waters in June 1983. Based upon a subsequent proposal by ENP and with the concurrence of the SFWMD, the gates at the S-12 structures were left fully open for two years, until 1985.

b. Description of Alternative Plan. As indicated above, a non-structural alternative known as the Flow-Through (FT) test evolved. This test involved operational changes only; no structural modifications were included. The existing project is shown on Plate 3. The FT test addressed only water deliveries into ENP through the S-12's. During the two-year FT test, two other tests were conducted which provided water to NESRS. The first of these tests was the "Thirty-Day Dry Season Test" described below.

(1) Thirty-Day Dry Season Test. This test was conducted during the dry season from 19 April through 18 May 1984. The purpose of the test was to determine the impacts of discharging large volumes of water into NESRS. Of particular concern were the impacts in the developed portion of the East Everglades. The test consisted of discharging the maximum volume of water possible through S-333 into the East Everglades. There were two constraints on S-333 discharges; the tailwater could not exceed a stage of 7.5 feet, NGVD, and the structure would be closed when water levels at gage G-596 exceeded the regulation schedule provided on Plate 4. A gage location map is provided as Plate 5. Groundwater gages and canal stages were monitored to ensure that there were no abrupt or threatening increases in water levels in the developed area. Because conditions were very dry prior to and during the test, most of the water discharged at S-333 was held in surface storage within NESRS. There was no observable rise in water level in the developed area as a result of the S-333 discharge. The L-31N borrow canal was found to have a dominant influence on water levels over a large area west of the levee. During the test, it was possible to discharge a large volume of water into NESRS (about 61,000 acre-feet). Because it was unlikely that such large releases would ever be made during the dry season, it was recommended that further testing be conducted during the wet season.

(2) Ninety-Day Wet Season Test. This test was conducted during the wet season from 1 August through 30 November 1984. The goal was to induce flows into NESRS for a period of up to ninety days under wet season conditions. The previous test had occurred during the dry season and the impacts of water releases during the wet season had yet to be determined. Large releases were more likely to occur during the wet season, so this second test was necessary to assess the impacts of such releases upon flood risk to the developed portion of the East Everglades. Water levels in the developed area were closely monitored to determine whether the risk of flooding was increased as a result of the test. Operating criteria for the test ensured that the developed portion of the East Everglades was not subject to an increased risk of flooding during the test period. Although rainfall during the test was below normal, the agreed upon operating criteria called for the closing of S-333 for two extended periods due to high water levels. It was possible to discharge for only 79 of the 90 days during the test period. The following conclusions were made: it is possible to use S-333 to divert relatively large amounts of water into NESRS during the wet season without increasing flood risks in the East Everglades developed area; the L-31N borrow canal operations can provide adequate groundwater drainage for the developed area to prevent increased flood risks; and the use of NESRS as a flow-way, by diverting water away from the S-12 structures, has a significant influence on the water level and overland flow rate within ENP near the Tamiami Trail. Hydroperiod changes in the center of the slough were difficult to distinguish with the test data. It was recommended that the next test coordinate the operation of S-333 with the operation of S-12.

c. Flow-Through (FT) Plan. A FT alternative plan was also modeled. This plan consisted of structural modifications to the C&SF Project - the same as for the first Rain-Driven plan but S-349 A, B, and C were added. Structure operations for this plan are described below:

(1) S-12. All S-12 structures would remain fully open with the gates raised clear of the water.

(2) S-333. The structure would remain fully open with the gate raised clear of the water.

(3) S-349. These structures would remain closed to prevent flow in the borrow canal. However, when water supply deliveries are required in south Dade County, the structures could be opened, if necessary, to convey the required flows.

(4) S-345. S-345 would remain fully open to allow free flow of water into WCA No. 3B. When water supply deliveries are required to south Dade County; however, the culverts could be closed, if necessary, to enable conveyance of the required flows. These structures and the associated discharge channels and containment levees would enable the transfer of water from WCA No. 3A into 3B.

(5) S-355. The structures would remain fully open to discharge water from WCA No. 3B into the L-29 borrow canal. The structure would be closed when the L-29 borrow canal stage exceeds the stage in WCA No. 3B to avoid reverse flow.

(6) L-28 Culverts (S-343A and B and S-344). The culverts would remain fully open.

(7) WCA No. 3A Regulation Schedule. Due to the above structure operations, the regulation schedule for WCA No. 3A would no longer be used.

(8) Seepage Levees. Construction of the ENP-South Dade County Conveyance System created a connection between the L-30 and L-31N borrow canals. S-335 was constructed in the L-30 borrow canal about 1 mile north of Tamiami Trail. Prior to construction of these works, water levels immediately north of Tamiami Trail were maintained about 1 to 1.5 feet higher than water levels in the L-31N borrow canal. After construction, canal stages below S-335 were lowered by 1 to 1.5 feet. Consequently, the head difference across L-30 (between WCA No. 3B and the L-30 borrow canal) from S-335 to Tamiami Trail was increased by 1 to 1.5 feet. This produced additional seepage inflow (from WCA No. 3B) to the L-31N borrow canal. As a part of this alternative, a seepage levee would be constructed across the southeastern corner of WCA No. 3B. It would connect L-30 at S-335 with L-29 at S-334.

d. Evaluation and Conclusion. As a result of the FT test, as well as the alternative, the water supply storage in WCA No. 3A was found to be essentially drained. Consequently, the project could not satisfy its authorized water supply function. Discharge to SRS was uncontrolled and, therefore, depended on upstream water management practices. The natural dry

season recession of the flow hydrograph was inhibited; and no systematic discharge was made to NESRS. The flow-through alternative could cause undesirable unseasonal dry season discharges. The project objectives of location and volume were met with this alternative, although the timing of deliveries would be impacted at times by water management operations for other project users. This alternative also severely drained designated critical habitat for the snail kite. Therefore, the alternative was dropped from further consideration.

48. PHASE 2: Rain-Driven (RD) and Restricted Rain-Driven (RRD) Alternatives.

a. Reason for the Phase. PL 98-181 authorized the Secretary of the Army to conduct an experimental program for delivering water to ENP. In further compliance with this authorization, another plan for testing was developed by SFWMD which provided water deliveries based on rainfall and evaporation in the basin. SFWMD developed a regression equation based on the historic correlation between basin rainfall-evaporation and flow to ENP. SFWMD also reviewed historic flow patterns and, based on the best available data, determined that 55 percent of the water deliveries should be made through S-333 into NESRS and 45 percent should be discharged at S-12 directly into ENP. This 55/45 split appeared to be a reasonable annual average distribution to restore historic conditions. Discharges are computed and adjusted on a weekly basis. Flood control discharges are added to the "rain-driven" water delivery component when water levels in WCA No. 3A exceed Zone E of the regulation schedule. The experimental program is being implemented through an iterative testing process with the concurrence of ENP and SFWMD. Each test uses and builds upon information obtained in prior iterations. Each of the tests conducted to date have included very specific operating criteria designed to ensure that the degree of flood risk in the developed portion of the East Everglades is not increased as a result of the tests. Legal agreements defining acceptable operating criteria for each of the tests were negotiated and agreed to by SFWMD and south Dade County agricultural interests. These agreements expired in 1987. The experimental program is ongoing and is being conducted concurrent with the preparation of this report.

b. Description of Alternative Plan. The rain-driven alternative involves several structural and operational changes from the existing project. Limited operational changes were field tested, and the combinations of structural and operational changes were modeled to determine their effects.

(1) Original RD Operational Test. The rain-driven water deliveries test was initiated in June 1985 and concluded in June 1987. Water deliveries to Shark River Slough were made through the S-12's and S-333, although use of S-333 did not begin until July 1985 when an agreement with south Dade County agricultural interests was reached. The total volume of water deliveries was computed weekly as the sum of two components: a rain-driven component and a regulatory component. The goal was to discharge 55 percent of total water deliveries through S-333 into NESRS and to discharge the remainder at S-12 directly into ENP. However, the test operating criteria included constraints designed to avoid increasing the flood risk in the developed area in the East Everglades. The test also included the limited use of WCA No. 3B to receive regulatory water releases from WCA No. 3A. This test included extensive

hydrologic and ecologic data collection by the Jacksonville District, SFWMD, ENP, and U.S. Geological Survey. Rainfall during the test was near normal and no flood damages were reported.

(2) Second RD Operational Test. The operating criteria utilized in the original 2-year rain-driven test from June 1985 through June 1987 was continued afterwards pending completion of negotiations between SFWMD and South Dade County agricultural interests. Negotiations for new test criteria were completed on 1 October 1987. At that time, new criteria were implemented through July 1988. Subsequently, the operating criteria are being continued through 1 January 1992 when the authorized test period expires.

The operating criteria for the second rain-driven water deliveries test were very similar to the prior rain-driven criteria. Computations of water deliveries were made in the same way and with the same frequency. The operating criteria were modified to allow slightly higher stages in the southern section of the L-31N borrow canal during dry season months to enhance the local water supply by allowing greater groundwater storage during a period when flood control is less of a problem.

c. Modeled RD Alternative. The modeled alternative involves several structural and operational changes from the existing project.

(1) Structural modifications. Three sets of new gated culverts (S-345) would be placed at intervals along L-67A between S-151 and S-333. Water discharged through the culverts would be conveyed into WCA No. 3B via canals with containment levees between L-67 A and L-67C. Two gated water control structures (S-355) would be placed in L-29 between L-67 and L-30 and would be used as the primary means of providing water deliveries to NESRS. A seepage levee would be constructed in the southeast corner of WCA No. 3B to reduce seepage from WCA No. 3B into the L-30 borrow canal. This levee would connect L-30 just north of S-335 and L-29 just west of S-334. The L-67 Extension levee would be removed and the borrow canal would be modified to eliminate canal flows. Two options were evaluated to modify L-67 Extension. One option would be to degrade the levee and add three new culvert structures in the remaining borrow canal. The other option would be to simply push the material from the levee into the borrow canal. Degrading L-67 Extension and filling the existing canal would restore full interaction between SRS and NESRS, without the need of operating any culvert structure. This alternative would restore the area to a more natural state and would be less costly since the levee material would not be removed from the site and no additional culverts would be required. A seepage levee would also be constructed west of and parallel to L-31N from Tamiami Trail southward to the developed portion of the East Everglades. This levee would prevent an increase in seepage inflow to the L-31N borrow canal due to higher water levels in NESRS.

(2) Operational modifications. The timing and rate of water deliveries would be composed of a rainfall-response component and a WCA No. 3A regulatory component. The sum of these two components would be the computed flow to be delivered to SRS. The rainfall-response component would be computed using weekly total rainfall excess depths for the current week and nine previous weeks. The regulatory component would be based on the three

station average in WCA No. 3A and would maintain the flood control capabilities of the area. Gages 3-3, 3-4, and 3-28 would be used to compute the average stage in WCA No. 3A. Computed SRS water deliveries would be split between S-12 (45 percent) and S-355, the L-29 structure, supplemented by S-333 when necessary (55 percent). Computation of water deliveries for this alternative is identical to the rain-driven tests.

During coordination of the preliminary alternative plans, several modifications were made to the original concept of the rain-driven alternative in iterative steps:

(3) RD Iteration #1. A new water discharge structure, S-349, was added to the structural and operational features of the rain-driven plan. S-349 would consist of three concrete headwall structures in the L-67 borrow canal. This would accomplish two functions: water discharges into WCA No. 3B via S-345 would be increased due to the higher headwater stages produced by S-349; and the southward drainage of northern WCA No. 3A would be retarded, thereby providing a more even distribution of water depths in the area.

(4) RD Iteration #2. The next iteration added a pump station (S-356) to the plan outlined above. This pump station would pump water from the L-31N borrow canal into the L-29 borrow canal and replaced the seepage which would have run immediately west of L-31N from L-29 southward to the flood mitigation area. Higher stages in NESRS will increase seepage into the borrow canal. This would adversely impact flood control in the adjacent basin and downstream. The seepage levee resulted in the loss of significant wetlands. Additionally, it was not entirely effective. Therefore, the pump station was selected as the preferred alternative.

(5) RD Iteration #3. Rather than constructing S-355 to discharge from WCA No. 3B into the L-29 borrow canal, the next iteration included degrading a section of L-29 to allow free flow of water from WCA No. 3B into NESRS. The western portion of L-29 would remain in place to reduce northward flows when large discharges are being made at S-333 and the tailwater stages in the L-29 borrow canal immediately downstream are high.

d. Restricted Rain-Driven Alternative. Another plan modeled during Phase 2 was the restricted rain-driven (RRD) water deliveries alternative which also involved only operational changes rather than structural modifications. This alternative is identical to the ongoing testing program. It consists of modifying the operation of the existing structural system to provide water deliveries across the full width of the historic Shark River Slough flow-way in accordance with the Rain-Driven formula used in the other Rain-Driven alternatives. However, operational restrictions would be placed on S-333 and modified operations of the L-31N borrow canal system would be included in this alternative to avoid increasing flood risks in the developed East Everglades area. No structural flood protection works would be provided in the East Everglades and no structural modifications would be constructed in WCA Nos. 3A and 3B. This alternative was identical to the test of Rain-Driven Water Deliveries conducted in 1985 and 1986 except that no drawdown of water levels in canals adjacent to the Frog Pond area would be included. The goal is for 55 percent of the total to be discharged through S-333 and the

remaining 45 percent to be delivered at S-12. Adverse flood control impacts on the residential area were avoided by drawing water levels down in the L-31N borrow canal when water levels in NESRS rose to threatening levels. This allowed excess groundwater to drain from the area.

e. Evaluation and Conclusion. Each iteration of the rain-driven alternative came closer to meeting the goal of 45 percent of flow through the S-12 structure and 55 percent of flow into NESRS. The original alternative was estimated to have 50 percent of the flow going through S-12 into SRS and 50 percent entering NESRS. The addition of S-349 changed this to 46 percent of flow through S-12 into SRS and 53 percent to NESRS. Further addition of the pump station 356 resulted in no change in these percentages of flow.

Conclusions drawn from the first rain-driven test are summarized below:

(1) Because of a maximum S-333 tailwater stage constraint, which would flood the Tiger Tail Indian camp if exceeded, the structure's year round discharges averaged about 38 percent of the total computed flows compared to the 55 percent target. During the dry season months however, this constraint was not significant, and it was possible for S-333 to discharge the full 55 percent of the target. It was possible to pass large volumes of water in NESRS during the test.

(2) During most of the test period, S-12 discharges met or exceeded the target.

(3) Total water deliveries during the test were about the same amount as the minimum monthly water delivery requirements of PL 91-282.

(4) Regulatory releases were necessary during both wet seasons of the test. During the 1985 and the 1986 wet season, the magnitude of the regulatory component was much greater than the rain-driven component. Several operational changes in 1986 affected these differences, such as: an increased intensity of implementation of the LOOP in 1986; much less storage in WCA No. 3A at the beginning of the 1986 wet season; use of S-339 and S-340 during the 1986 wet season which raised water levels in Southern WCA No. 3A; and the temporary abandonment of the WCA No. 2A drawdown in the 1986 wet season.

(5) It was not always possible to maintain stages in the L-31N borrow canal system at the drawdown levels specified in the test's operating criteria. However, during the test, the peak canal stage upstream of S-331 was lower than peak stages that occurred during all but four years since 1967. Also, wet season water levels in the canal were lower than groundwater levels on both sides of the canal.

(6) Water levels in NESRS were restored to an approximation of natural conditions. The influence of lowered L-31N borrow canal stages during wet conditions were experienced in the slough.

The actual testing of the rain-driven alternative showed that the alternative did meet the study objectives. Water deliveries across the full width of SRS were restored thereby stimulating marsh productivity, favoring

deposition of native peat soil, reducing fire frequency, and slowing the spread of exotic plant species. This alternative also provided limited flows into WCA No. 3B. The study objectives of location, timing and volume of water were met. It was therefore decided to complete further testing of the rain-driven alternative to fine tune components of the plan.

Based on RD iteration #3, discharges out of WCA No. 3B are generally limited because of a lack of head across L-29. When the capacity to discharge water out of WCA No. 3B is not adequate to accomplish the prescribed delivery, S-333 is used to supplement discharges to NESRS. This raises the L-29 borrow canal stages and further reduces, eliminates, or at times reverses the head across L-29. With a section of L-29 removed, the following problems are experienced: water will flow from L-29 northward into WCA No. 3B at times and as a result, could artificially extend the hydroperiod in WCA No. 3B or reverse the water level recession; northward flow of water would reduce the operational ability to provide 55 percent of water deliveries to NESRS; less of the water deliveries to NESRS would originate in WCA No. 3B and more would originate in WCA No. 3A; WCA No. 3B would not serve as effectively as a temporary retention area during major flood releases from WCA No. 3A; during dry times, the lower portion of WCA No. 3B could be over-drained; and there would be no operational flexibility to take advantage of improved water management strategies developed during the continued iterative testing process. Therefore, S-355A and B were retained as components of the recommended plan.

The RRD alternative restricted flows to ENP. Under this alternative, flows to NESRS would be limited to less than the 55 percent goal. There were regional water supply losses, limits on wet season flow to NESRS, potential adverse impacts in C-111 to roseate spoonbills, crocodiles and possibly agricultural flood protection. Unnatural water distribution due to L-67 Ext. and L-31N impacts. The four corners hydrology still exists.

This alternative did not meet the study objective of volume of water so it was therefore dropped from further consideration.

49. PHASE 3: Basic Rain-Driven (BRD) and Modified Rain-Driven (MRD) Alternatives.

a. Reason for the Phase. After additional modeling of the rain-driven plan with various alternative measures and coordination of the results with the cooperating agencies, a consensus was developed on the preferred plan. This plan is referred to as the Basic Rain-Driven (BRD) plan. During the final phases of coordination with the U.S. Fish and Wildlife Service (USFWS), it was concluded that the BRD plan would jeopardize the continued existence of the snail kite, a Federally listed endangered species. Therefore, alternative operating plans were investigated in order to avoid adverse impacts on snail kite habitat. These investigations resulted in development of the Modified Rain-Driven (MRD) plan which USFWS feels would not jeopardize the continued existence of the snail kite.

b. Description of BRD Plan. The basic rain-driven (BRD) plan involves structural and operational modifications to the existing C&SF project. Plate 6 shows these modifications. A description follows:

(1) Structural modifications. Three new sets of gated culvert structures (S-345A, B, and C) would be placed along L-67A between S-151 and S-333. Water discharged through the culverts would be conveyed into WCA No. 3B via discharge canals with containment levees between L-67A and L-67C. A set of three concrete headwall structures, S-349A, B, and C would be built in the L-67A borrow canal to increase water discharges into WCA No. 3B. Two gated spillways (S-355A and B) would be placed in L-29 between L-67 and L-30 to provide up to 55 percent of the total water deliveries to SRS. L-67 Extension would be removed and the borrow canal would be filled to eliminate canal flows. These modifications would allow full hydrologic interaction between portions of the slough that are currently separated by the existing levee. S-334 would also be modified.

(2) Operational modifications. Water deliveries would be comprised of a rainfall-response component and a WCA No. 3A regulatory component. The sum of these two components would be the computed flow to be delivered to SRS. The rainfall-response component would be computed using weekly total rainfall excess depths for the current week and the previous nine weeks. The regulatory component would be based on the currently used three station average stage in WCA No. 3A and would maintain the flood control in the area. Computed SRS water deliveries would be split between S-12 and S-355 supplemented by S-333, when necessary.

This basic rain-driven (BRD) alternative was developed by making some changes to the Rain-Driven alternative based upon input from the local sponsor and other agencies, as well as in-house hydrologic modeling. The basic rain-driven plan would be a major departure from the minimum delivery schedule for managing water deliveries to ENP. First, the delivery schedule would be based on a rainfall-based regression model which simulates natural hydrologic conditions that existed during pre-development, thus providing more natural timing and quantities of water deliveries than the minimum schedule. Rates of delivery would be changed on a weekly basis as in the current experimental program. Second, WCA No. 3B would be included in the delivery path of water from WCA No. 3A to ENP. In addition, the WCA No. 3A regulation schedule would be altered. Transition zones would be added to prevent sudden releases of water from WCA No. 3A into SRS. Plate 16 shows the regulation schedule for WCA No. 3A. Figure 10 shows how structures would be operated with the added transition zones.

c. Description of MRD Plan. In an effort to prevent adverse impacts on the snail kite habitat, the Basic Rain-Driven alternative was modified. The southern portion of WCA No. 3A is designated critical habitat for the snail kite. It has served as an important drought refugia for the snail kite because it has been artificially impounded as a result of the adjacent project works. One goal that was accomplished by the BRD was to re-establish natural hydrologic conditions which resulted in more frequent dry outs of the critical habitat. The modified alternative, known as the modified rain-driven (MRD) alternative, kept the same structural and operational functions as the BRD

alternative except operational features were added to maintain a kite drought-refuge in WCA No. 3A. The S-349 structures were assumed to be open at all times for this alternative. Additionally, water supply transfers from Lake Okeechobee to WCA No. 3A would be made when the average stage in WCA No. 3A is equal to or below 9.0 feet. Gages 3-3, 3-4, and 3-28 would be used to compute the average stage in WCA No. 3A. This plan would also include a 15 percent reduction in water supply discharges from WCA No. 3A when the L-67A borrow canal stage is equal to or below 7.5 ft., NGVD. These restrictions were implemented to minimize impact on endangered species. This plan is shown on Plate 7.

d. Evaluation and Conclusion. The evaluation of the Basic Rain-Driven alternative shows that outflows from WCA No. 3A would be greater than those in the Base Condition. Hydroperiods in the area immediately north of Tamiami Trail would be reduced. This area is designated critical habitat for the snail kite and would be adversely impacted. A biological opinion by the U.S. Fish and Wildlife Service concerning the potential adverse impacts of this plan pursuant to Section 7 of the Endangered Species Act, as amended, concludes that the Basic Rain-Driven Plan "would jeopardize the continued existence of the snail kite and adversely modify its critical habitat".

Under the BRD alternative, the timing of wet season peaks of water deliveries and length of recession curves would vary each year in response to variations in seasonal rainfall. Therefore, the study objective of timing of water was met. The volume objective was also met under the BRD.

Modeled flows under the BRD and MRD alternatives showed a gradual rise in regulatory water releases in response to the start of wet season rainfall, and the timing of these flows varied annually in response to the observed rainfall conditions. The impacts from sudden regulatory water releases were tempered by dissipating flooding across a broad front directly into NESRS. The combination of a transition zone in the release schedule and redirection of flows strongly improved the performance of these two alternatives. The objective of redistributing flows is best met by the BRD and MRD alternatives. These alternatives included new structures to move water between WCA No. 3A and 3B, and then directly into NESRS.

The water deliveries had more natural timing under the MRD and BRD Plans. The timing of wet season peaks and length of the recession curves varied each year in response to the cessation of rainfall. The MRD alternative is much more effective at maintaining standing water in southern WCA No. 3A, which is critical habitat for the snail kite. Under average dry season conditions, the MRD alternative showed an overall decrease in water depths compared to the Base Condition. The MRD model shows minor but extensive increases of flooding in WCA No. 3A, mixed effects in WCA No. 3B, reduction of flooding in the Park, and very sizeable increases of flooding in NESRS (locally, about an additional 15 to 50 percent of the time).

The MRD alternative would not jeopardize the snail kite, but would incidentally take kites and thus required the imposition of terms and conditions to limit this take. Neither the MRD nor BRD plans would jeopardize the wood stork.

Construction of the structural features of the MRD and BRD plans would result in a net loss through dredging and filling of about 166 acres of vegetated wetlands.

Because the BRD was determined to jeopardize the continued existence of the snail kite it was dropped from further consideration. The MRD alternative was carried into the next phase for further evaluation.

50. PHASE 4: Modified Rain-Driven (MRD) and Modified Minimum Delivery (MMD) Alternatives.

a. Reason for Phase. The modified rain-driven alternative was carried into Phase 4 and was compared to another alternative, the modified minimum delivery (MMD) alternative which was also developed to avoid any impacts on snail kite habitat.

b. Description of MMD Plan. Under the MMD alternative, no operational changes would be made to the PL 91-282 procedures used for the existing project, but two major structural modifications to the existing project would be made. L-67 Extension would be degraded; and pumping stations, a levee and canal system would be constructed to provide flood mitigation for areas that would otherwise be adversely impacted. Operations would be identical to the base condition. Water deliveries to ENP would be made through the S-12 structures. Structural modifications proposed under this alternative are shown on Plate 8. These modifications would allow full hydrologic interaction between portions of the slough that are currently separated by the L-67 Extension levee. Also, the uneven flow distribution caused by the borrow canal would be improved.

The MRD alternative was the same as described under Phase 3.

c. Hydrologic Comparison of Alternative Plans. Flows through the existing and proposed structures for four alternative plans analyzed are shown on Table 8. Also shown are inflows and outflows from WCA No. 3A as well as projected water flows distribution for the various plans. Table 9 shows median stage changes relative to the Base Condition for various gages. Gage locations can be found on Plate 5, except gages TSRP and TSHO which are located southwest and west of the Frog Pond area. This area is surrounded by Levee 31 West (see Plate 3). The median stage was defined as the corresponding stage to the fifty percent exceedence on a frequency exceedence curve. Table 10 shows hydroperiod changes relative to the Base Condition for the alternative plans analyzed. The hydroperiod days were determined from frequency exceedence curves and was defined as the product of the average percent of time stages, for various gages indicated, exceeded average ground elevations times 365 days. Table 11 shows peak stage changes relative to the Base Condition for selected gages.

d. Evaluation and Conclusion. The model of the MMD alternative produced abrupt seasonal spikes of stage increases from regulatory water releases with rapid flow increases occurring many years between July and August, regardless of the timing of local rainfall. The MMD allows flows from the S-12 structures to run toward NESRS. In the absence of large regulatory releases,

flows consistently peaked in October and receded at a fixed rate through January. Under average dry season conditions the MMD alternative showed an overall decrease in water depths, compared to the base condition. Under below-normal dry season conditions, the percentage of the basin that dried completely was substantially reduced.

The MMD alternative has some of the same shortcomings as the base condition with the following exceptions. Although water releases are being made only through S-12, removal of L-67 Extension would allow some interaction with NESRS. Also, with the construction of the levee and canal system in the developed East Everglades, S-356 would provide additional flows into NESRS. This alternative would provide an annual average of 34 percent more water than the base condition, thereby meeting the study objective relating to volume of water. There would also be no adverse effects on Tamiami Trail under the MMD. Although this alternative is the plan with the fewest structures and avoids adverse effects on the drought-refuge by making no significant changes in the WCA No. 3A water budget; however, it fails to meet the location objective to restore flow distribution across the entire width of SRS.

The net loss of wetlands, as a result of construction of the structural portions of the MMD plan, would be approximately 94 acres.

The timing of water deliveries was more natural under the MRD plan. The timing of wet season peaks and length of the recession curves varied each year in response to the cessation of rainfall. This plan is also effective at maintaining standing water in critical habitat for the snail kite. Under average dry season conditions, the MRD alternative showed an overall decrease in water depths; yet with below normal dry season conditions, the MRD alternative substantially reduced the percentage of the basin that dried completely. The MRD model showed minor but extensive increases in flooding in WCA No. 3A, mixed effects in WCA No. 3B, reduction of flooding in the Park, and very sizeable increases of flooding in NESRS.

The study objectives of location, timing and volume of water were all met by the modified rain-driven plan. It also did not jeopardize the endangered snail kite. It is therefore the recommended plan for modifying water deliveries to Everglades National Park.

51. National Economic Development Plan. The "Principles and Guidelines" (10 March 1983; also called the "P&G") specify the rules to be followed by Federal agencies in planning water resources projects. The P&G require that "the alternative plan with the greatest economic benefit consistent with protecting the Nation's environment (called the national economic development plan, or the "NED plan") is to be selected unless the Secretary of a department or head of an independent agency grants an exception when there is some overriding reason for selecting another plan, based upon other Federal, State, local and international concerns". The NED plan is selected from the array of alternatives under consideration, and is the plan that reasonably maximizes net national economic development benefits. These monetary benefits are calculated in accordance with the evaluation procedures for specific

benefit categories included in the P&G. In most cases, an economic analysis of alternatives' monetary benefits is conducted using the P&G evaluation procedures; the results are then used to identify the NED plan.

In the "Everglades National Park Protection and Expansion Act of 1989" (Public Law 101-229), the Congress recognized the nonmonetary, environmental significance of the Everglades, and stated that the project modifications to the Central and Southern Florida project, as recommended in this General Design Memorandum, "are justified by the environmental benefits to be derived by the Everglades ecosystem in general and by the park in particular and shall not require further economic justification".

The purpose of the alternatives plans considered in this study is to produce nonmonetary environmental benefits by improving water deliveries to Everglades National Park. Alternatives that satisfy this purpose will also produce incidental benefits that could be evaluated in monetary terms, such as flood damage reduction, water supply, and recreation benefits. However, in view of the Congressional direction provided in Public Law 101-229, a traditional economic analysis, using the P&G evaluation procedures, was not undertaken during this study (with the exception of the evaluation of the East Everglades mitigation measures). In the absence of an economic evaluation, no NED plan may be identified.

52. Summary. The environmental, economic and social and cultural effects of each alternative are shown in Table 12. All the alternatives resulted in improvements to the environmental categories evaluated with the exception of endangered species and wading birds. The BRD and MRD plans would be expected to result in a loss of wading bird feeding habitat and a reduction in nesting success. The endangered snail kite was jeopardized by the BRD and adversely affected to a lesser extent by the MRD. The MRD plan would improve airboat access to WCA No. 3A. None of the alternatives had adverse impacts on the cultural resources of the study area. The BRD and MRD plans would require slightly more water supply releases from Lake Okeechobee, but during drought years these releases would be less than the Base and MMD.

During droughts it may not be possible for lake Okeechobee to deliver water in sufficient quantities to prevent low water conditions in WCA No. 3A. These conditions would occur naturally under all alternative plans including the Base Condition. Stages in the area could drop below desirable levels, despite any attempts to deliver maximum allowable discharges. Another factor affecting WCA No. 3A is the water allocation process. Under this concept, all water users in the region must share adversity during periods when Lake Okeechobee stages fall within the "Warning Zone" of the Water Shortage guidelines of the SFWMD.

A 3 percent increase in water supply releases from the lake would occur with the BRD and a 12 percent increase with the MRD plan. These impact on water supplies in the region are not considered significant since both alternatives would allow for greater ground water recharge in WCA No. 3B, and would better serve the water supply needs of the ENP-South Dade Conveyance system. Water supply impact for the BRD, MRD, and MMD are compared to the Base Condition on Table 8A and Figures 11 and 12. Since the MRD allows for greater water supply releases, Lake Okeechobee regulatory releases are expected to decrease due to a redistribution of storage in the system.

The study objectives of location, timing, and volume for each alternatives are addressed in Figure 2. The location objective is shown pictorially to show the effects of each alternative on the four areas (WCA Nos. 3A, 3B, ENP, and NESRS) under investigation.

The views of other Federal and State agencies, East Everglades residents, agricultural interests, Miccosukee Indians and others are included in Table 13. Although the MRD plan is not supported by all groups listed, the agencies have agreed if a preferred operating strategy cannot be developed before completion of construction of the project, the MRD operating strategies will be implemented.

The alternatives were also compared to plans of others and are summarized in Table 14. The alternatives investigated are consistent with other water management plans for the Everglades area with the exception of the West Dade County Wellfield.

The relationship of the alternatives investigated to environmental statutes and other environmental requirements is shown in Table 15. All alternatives, except the BRD, were found to be in compliance with applicable statutes, executive orders and memorandums.

G. MITIGATION AND MONITORING MEASURES

53. General. In addition to the basic alternative plans developed to meet the study objectives of location, timing, and volume of water to be delivered to ENP, several measures were required to be added to the plans as shown in the following diagram. These measures included mitigation for induced flood damages in the East Everglades and in the Osceola and Tiger Tail Indian Camps, modifications to Tamiami Trail, relocation and modification of S-334, monitoring effects in the East Everglades agricultural area, and provisions for hydrologic and snail kite monitoring.

Alternatives Requiring Mitigation/Monitoring

	FT	RD	RRD	BRD	MRD	MMD
East Everglades Mitigation	X	X	0	X	X	X
Indian Camps	X	X	0	X	X	X
S-334 & Tamiami Trail	X	X	0	X	X	0
Agricultural Area Monitoring	X	X	X	X	X	X
Snail Kite Monitoring	NC	NC	NC	NC	X	0

Note: X indicates inclusion; 0 indicates not required; NC not considered

54. East Everglades Mitigation.

a. Reason for Phase. By increasing water levels in NESRS under the various alternatives evaluated for modified water deliveries to ENP, groundwater elevations in some of the adjacent developed area of East Everglades would be increased. As a result, the volume of groundwater storage available to retain rainfall runoff would be reduced and the area would be more susceptible to flood damages. The additional increase in flood depths would range from about 0.3 feet in the north part of the residential area to about 0.1 feet in the agricultural area. According to PL 98-181, the Secretary of the Army is "authorized to construct necessary flood protection measures for protection of homes" in the area affected by any modification of such delivery schedule.

Damages that may be attributable to the additional flow of water are as follows: deterioration in unimproved roads due to increased groundwater; damage to septic tank systems due to increased groundwater; damages to potable wells due to septic tank problems; and damages to residences due to flooding and increased groundwater.

The East Everglades residential area is not provided any direct flood protection by the C&SF Project, although it does receive some incidental benefits due to adjacent project works. The area is subject to frequent flooding problems. Much of the development in the area occurred during the 1970's, a decade of generally below normal rainfall with no major storms. In 1981, Tropical Storm Dennis flooded the area for several months. The Governor of Florida declared it to be a disaster area and the National Guard was called upon to transport residents from L-31N (the area to the east is provided flood protection by the C&SF Project) to their homes. There was also a concern with the flooding of septic tanks and contamination of groundwater.

There are only two paved roads in the area, Richmond Drive and Howard Drive. All other roads are privately owned dirt roads at ground level. These roads are frequently inundated and as a result require a great deal of maintenance. Many residents must travel for several miles on dirt roads to reach their homes. Traveling on flooded roads that require repairs makes access to homes extremely difficult.

Since 1985, when L-31N borrow canal stages have been manipulated to prevent adverse flood impacts in the area due to the testing process, the level of flood protection has been enhanced. In other words, operating criteria associated with the testing has provided a greater level of flood protection for the area than would exist without the testing. However, in 1986, following a dry period when no water deliveries were being made to the Park, a sudden storm flooded the area. Flood waters inundated roads long after water levels had subsided in the adjacent areas. Roads have also been flooded during several other years in the 1980's.

About 500 acres of agricultural land exist within the residential area. In addition to commercial agriculture, many of the residents have fruit trees. Flood damages begin when the groundwater levels rise into the root zone of the plants and trees.

Because the area is currently flood prone, even minor increases in flood depths and durations would result in an unacceptable living condition.

The impacts of the project rarely would flood the area directly if no flood mitigation is provided. However, the project would cause higher groundwater levels in the area which would reduce the available groundwater storage. Consequently, the frequency of flooding would be increased. Flooding in the area is generally caused by a combination of factors; antecedent groundwater levels, rainfall, and water levels in adjacent canals. Individually, any one of these factors would have a significant impact on flooding.

If the project was implemented without a flood mitigation component and flooding occurred in the area, it is likely that litigation would result. For a specific flood event, it would not be possible to conclusively determine to what extent, if any, the project contributed to the flooding.

Studies by the SFWMD indicate that rainfall over the last two decades has been significantly below normal. A return to more natural rainfall patterns in the future will exacerbate the flood problems in the developed East Everglades.

b. Description of Alternatives. Two basic approaches were investigated to reduce or prevent increased flood damages in the developed East Everglades area. These approaches were a non-structural plan which involved acquisition of all lands adversely impacted by the increased water depths and various structural measures.

(1) Non-structural. This plan involves the acquisition of the necessary land interest in the eight and one-half square mile developed area to eliminate claims from land owners for damages incurred due to modification of the C&SF project. This alternative would mitigate for damages resulting from project implementation and also provide additional infinite flood protection since the structures located in the flood plain would be removed. Acquisition would consist of fee title to those ownerships which have residences, businesses, or farms, and acquisition of perpetual flowage easements for lands which are currently undeveloped. There are 5,400 acres within the area, with an estimated land value of $43,520,000 and $28,773,350 in improvements, which would require acquisition. Relocation costs pursuant to Public Law 91-646 would add an additional cost of $5,920,000 to this plan for a total maximum cost of $78,213,350. If only flowage easements were to be purchased, the total cost would be reduced to $43,352,000.

(2) Structural. An array of structural alternatives were also developed. Among the structural alternatives proposed for mitigation of flood damages that would result from implementing the project, the feasibility of using a single pumping station was considered first. In addition, several alternatives considering more than one pumping station were also developed.

Among the plans considered, several included a single pumping station. The first two alternatives of this type, Plans A and C, contemplated a single station with capacities of 840 and 1330 cfs, respectively. In conjunction with a single levee parallel to L-31N, both plans also provided a seepage canal at the residential protection levee with discharge flowing westerly into ENP and Shark River Slough. These alternatives were not acceptable to Everglades National Park because of the requirement to provide a discharge channel within the Park boundary. The third alternative evaluated would collect flood waters in the residential seepage canal and flow northerly along the L-31N borrow canal and would be pumped into the L-29 borrow canal. A pump station located near L-29 would require a 2,300 cfs pump station and canal enlargement. With this arrangement, most of the pumped water would come from the vicinity of the pump station thus providing very little flood mitigation in the residential area. Groundwater levels in this region are closely regulated and managed. Since drawdowns increase seepage and surcharges induce flooding, with existing constraints, more than one pump station is needed for moving flood waters from the residential area to Shark River Slough. Figures 13 and 14 show water level profiles for a single and a double pumping station for flood mitigation of residential area. Figure 15 shows a comparison of water level profiles for a single and a double pumping

station. A single pumping station would not fully mitigate floods in the residential area. Its size would increased greatly with additional seepage incurred by excessive drawdown of the L-31N borrow canal. A two pumping station arrangement addresses the flood mitigation problem in a more economical and effective way.

The remaining alternatives, Plans B and D through G would utilize two pumping stations to mitigate for flood damages resulting from implementation of the project. Plan B used the same double levee system to provide additional flood control for the East Everglades area. Plans D through G, would use a pump station in place of the double levee system along L-31N to provide mitigation.

(a) Plan A. As shown on Plate 9, the system would be a double levee from L-31N immediately north of the area running along the northern and western boundary of the residential area. The double levee would be continued as far south as Richmond Drive. A single levee running along Richmond Drive would tie into the double levee on the west and L-31N on the east. An interior canal system would be provided to collect seepage water from NESRS. Three weir structures would be provided to prevent excessive drawdown of canal stages. Excess water would be pumped via an 840 cfs pump station located at the northwest corner of the area. The pump station would pump from the interior canal in a northwesterly direction directly into NESRS.

(b) Plan B. North of Richmond Drive, the system would be identical to Plan A except the single levee running along Richmond Drive would not be included. The double levee would be continued southward from Richmond Drive along the western edge of the agricultural area. At the southern extremity of the agricultural areas, the double levee would run directly eastward to tie into L-31N. An interior canal would be provided south of Richmond Drive to collect seepage inflow from NESRS. The canal would be roughly parallel to the double levee about 0.5 to 0.75 miles to the east. Under a flood condition, seepage water that flowed through the double levee would flow overland into the canal. The distance of the flow between the levee and canal would provide a significant energy loss and, therefore, would reduce the total inflow to the canal. Full mitigation would not be provided for the area between the canal and levee. A 400 cfs pump station would pump from the interior canal directly into NESRS. This plan is shown on Plate 10.

(c) Plan C. The levee and canal alignments for this alternative would be identical to Plan A and is shown on Plate 11. Canal sizes would be increased to convey additional flows and the pump station capacity would be 1,330 cfs.

(d) Plan D. This plan, shown on Plate 12, would be implemented without a double levee along L-31N. Instead, a 500 cfs pump station (S-357) would be provided in L-31N at the residential area. Excess seepage water from NESRS would be pumped from the L-31N borrow canal into the interior canal system for the residential area flood protection. S-357 would be located about 0.5 mile west of L-31N on a canal that would convey water from L-31N borrow canal to a pump station (S-356) located in the northwest corner of the protected area. A 240-foot section of canal west of S-357 would be lined with

an impervious material to reduce return seepage from the pump outlet canal to the intake canal when the pump is in operation. Although the area that would be provided full protection is the same as Plan A, the levee alignment would be moved to reduce the total area inside the levee, thus, minimizing adverse effects to wetlands. There would be little overland flow within the protected area unless the capacity of the system is exceeded. A canal would be provided immediately inside the levee to collect seepage water from NESRS and convey it to a pump station. Excess water from L-31N borrow canal and excess flood water from the residential area would be pumped via S-356 directly into NESRS. S-356 would have a capacity of 1,340 cfs; 840 cfs capacity for residential area flood protection and 500 cfs capacity to pass excess water from L-31N borrow canal (pumped at S-357).

(e) Plan E. The levee alignment for this plan is the same as for Plan D. This alternative, shown in Plate 13, would also be constructed without an L-31N seepage levee. Instead, a pump station, S-356, would be located adjacent to S-334 and would pump excess seepage water from the L-31N borrow canal into the L-29 borrow canal. S-356 would have additional capacity to pass flood waters from the residential area. With Plan E, flood waters from the protected area would be pumped via a 470 cfs pump station, S-357, into the L-31N borrow canal. The capacity of S-356 would be 900 cfs; approximately 400 cfs capacity for residential area flood waters and 500 cfs capacity for excess seepage water from L-31N borrow canal. S-357 would be located in an interior canal connecting to L-31N borrow canal. It would be about 0.5 mile west of L-31N. A 240-foot canal segment just east of S-357 would be lined with tremie concrete to reduce return seepage around the pump station from 136 cfs to 70 cfs.

(f) Plan F. This plan is the same as Plan E, except the south levee was eliminated and therefore the raising of Richmond Drive was no longer necessary. The height of the outer levee was also reduced by approximately five feet. Details of this plan are shown on Plate 14.

(g) Plan G. This plan, shown on Plate 15, was developed as a cost savings alternative to plan E. Plan G relocated the S-357 pumping station to the northern portion of the residential area. This move eliminated the acquisition of rights-of-way needed for construction of the interior canal connecting to L-31N, avoided the construction of access roads and bridges, and decreased the initial and maintenance costs associated with Plan F. In addition, relocation of S-357 would avoid the potential hazards of having a canal across the middle of the residential area. With Plan G, portions of the seepage collector canal would be modified to allow for greater conveyance capacity. Due to higher seepage at the proposed location, S-357 capacity would be increased to 533 cfs. The capacity of S-356 would be 950 cfs to reflect the increase in pump size at S-357. As Plan F, the height of the outer levees was reduced by approximately five feet, and S-357 would be about 0.5 mile west of L-31N, and about 0.5 miles north of Canal 1. A short canal segment just east of S-357 would be lined with tremie concrete to reduce return seepage from the outlet side of the pump to the inlet canal side. Seepage of about 86 cfs would occur from the L-31N borrow canal back to the inlet canal west of S-357 when this pump station is operating at capacity.

c. Evaluation and Conclusion. The primary objective in development and selection of a mitigation plan for the developed East Everglades area was to minimize cost. Additionally, the mitigation plan must be consistent with the general project goal of restoring natural hydrologic conditions within the Everglades. Table 16 shows the comparison of the various alternatives which were investigated.

The structural alternatives in the Rocky Glades area were evaluated using the 1x1 model. The 2x2 model was used to size and evaluate S-356. When the initial array of structural mitigation plans was developed, the extent of potential flood impacts that required mitigation was uncertain. As a result, structural mitigation plans were developed for the residential area and a plan was also developed that would address both the residential and agricultural areas. Initially, both minimal and higher levels of protection were considered; however, it was soon evident that not even minimal protective measures were economically justified. So, all subsequent alternatives aimed at mitigation only. All the structural alternatives for the residential area also met mitigation requirements for the agricultural area; therefore, separate protective works for this area were found unnecessary. Since a NED plan is not required, all benefits derived from the flood mitigation of the residential area are incidental.

Plan A was the initial attempt to meet the minimum required mitigation. An 840 cfs pump discharging into NESRS was determined necessary to reduce flood stage a uniform 0.2-foot. This size proved adequate for the 1969-1982 simulation period, but when checked for the 100-year and SPF flood events, not all grid nodes met mitigation requirements even though average annual damages were more than mitigated. Plan A also included a seepage levee about 1,000 feet west of L-31N from Tamiami Trail southward to the flood mitigation area. This levee was intended to prevent additional seepage flows into the L-31N borrow canal. Overall this plan would result in unacceptable impacts on the Everglades ecosystem. Pumping directly into NESRS would not be consistent with the goal of restoring natural hydrologic conditions. Under some conditions, water would be introduced along the edge of NESRS as a point source. The seepage levee would destroy some of the Everglades habitat by filling for the levee "footprint". Also, the 1,000 foot strip between the seepage levee and L-31N would be lost as a functioning component of the Everglades system. Inflows would consist of direct rainfall and seepage; outflows would consist of seepage. The U.S. Fish and Wildlife Service (USFWS) also objected to the additional area enclosed by the residential levee that could have remained undisturbed wetlands. The USFWS and ENP opposed this plan. Therefore, Plan A was dropped from consideration.

Plan B added protective works for the agricultural area to Plan A. A pump size of 404 cfs, sufficient to lower water levels 0.2-foot, was chosen. This more than met mitigation requirements when modeled, but caused slightly higher stages in the residential area than Plan A. The additional water going into Taylor Slough apparently caused a backwater affect extending north above the residential levee. The need for separate protective works was dropped soon after as explained in the first paragraph. All the objections noted for Plan A apply to Plan B.

Plan C represented a higher level of protection than mandated by Congress. This was to see if additional flood control benefits might be economically justified. Plan C was identical to Plan A except the pump of 1330 cfs was sized to provide complete protection from the 1969 flood which is between a 10- and 15-year frequency. This alternative had the greatest reduction in average annual damages, and would result in about $856,500 of additional average annual reductions in damages. However, this was not adequate to offset the added cost of Plan C. It was also environmentally objectionable for the same reasons as Plans A and B.

Plan D was similar to Plan A and was developed to avoid the loss of Everglades habitat associated with the L-31N double levee. The L-31N double levee was eliminated and a 500 cfs pump station was added to remove excess seepage water from L-31N and discharge such water into a canal through the residential area. A 1340 cfs pump would discharge excess residential area water and L-31N seepage water westward into NESRS. This plan was even less successful than Plan A in mitigating flood levels. The plan is also inconsistent with the goal of restoring natural hydrologic conditions. Therefore, it was dropped from consideration.

Plan E was developed to prevent the adverse impacts to the Everglades ecosystem associated with Plans A through D. The residential area runoff was pumped east into L-31N; no double levee was called for along L-31N; and the residential runoff and excess seepage along L-31N was pumped into L-29 borrow canal to be reintroduced into NESRS through 53 culverts beneath a 10-mile stretch of Tamiami Trail. As a result, the natural flow pattern can be maintained. This plan met all mitigation requirements in the Rocky Glades area.

Plan F is identical to Plan E except costs were lowered by reducing levee heights by 6 feet to 1 foot above the SPF stage. All previous plans used high outer levees to protect against hurricane wind setup occurring in conjunction with the SPF stage in NESRS. This eliminated the need for the south levee along Richmond Drive. Maximum wind setup stage inside the low levee area would be only 0.4 foot higher than with high levees but not any greater and probably less than under Base Conditions. Flood mitigation is the same as Plan E.

Plan G is essentially the same as Plan F except the residential pump was moved two miles north to reduce the impact on existing development. Plan G was then compared to the "non-structural" alternative of acquiring adequate real estate interest in the area. Because the cost of Plan G is less than the cost of the non-structural plan, Plan G is recommended for implementation.

(1) Economic Analysis. The economic benefits from a water resource project are the value of increases to the output of the nation and cost savings in maintaining a given level of output. Water projects are typically formulated to provide the maximum net National Economic Development (NED) benefits consistent with protection of the environment. The project for modified water deliveries to Everglades National Park was not formulated to maximize NED, but rather to secure the environmental benefits to be derived by

the Everglades ecosystem in general and by the park in particular. For this reason, traditional NED benefit-cost analysis is inappropriate.

The purpose of economic analyses conducted for the project was to identify any adverse impacts on residential and agricultural areas (i.e., potential for increased flood damage) associated with the alternative plans, in order to determine whether mitigation measures would be needed. Residential and agricultural damages were estimated for the base condition, the No Action alternative (i.e., modified deliveries without mitigation) and each of the alternative plans. In order to simplify the analysis, estimates of agricultural damage focused on maximum potential flood damages associated with each alternative.

The No Action plan would result in increased crop damage potential for 6 of the 15 grid squares located within the East Everglades residential area and 6 of the 13 grid squares located within the southern agricultural area. Plan G, the recommended plan, completely mitigates the potential for increased agricultural damage to those 12 grid squares, and would also reduce potential crop damage for an additional 6 grid squares located within the East Everglades residential area and 2 grid squares located within the southern agricultural area.

For each plan except the No Action alternative, flood damages were calculated to be less than under the base condition. This result indicates that each of those plans is sufficient to mitigate for the increased damages which would result from the No Action plan. Table H-36 in the Economic Appendix shows the average annual maximum value of crop losses over the entire study area to be $6.8 million under the base condition. Under Plan G, the recommended plan for mitigation in the East Everglades area, the average annual maximum value of crop losses was calculated to be $1.3 million less than under the base condition. Table H-34 of the Economic Appendix shows maximum damage to crops located within the East Everglades residential area and Table H-35 shows maximum damage to crops located in the southern agricultural area. Under the base condition, maximum crop damages were estimated at $3.2 million for the residential area and $3.6 million for the southern agricultural area; the recommended plan would result in a reduction of those losses to $2.2 million and $3.3 million, respectively.

Agricultural damages that would occur under the base condition and all alternatives would be less than indicated above. It was assumed that all crops were "in the ground" when the storm events occur. However, many of the crops are grown on a seasonal basis and are susceptible to flood damages only during part of the year, generally, the winter growing season.

Residential damages and damages to roads were also evaluated for the alternative plans, the base condition, and the No Action Plan. For each plan except the No Action alternative, flood damages were calculated to be less than under the base condition. This result indicates that each of those plans is sufficient to mitigate for the increased damages which would result from the No Action Plan. Table H-37 in the Economic Appendix shows the average annual cost of temporary relocation for residents to be $482.1 thousand under the base condition. Under Plan G, the recommended plan for mitigation in the

East Everglades area, the average annual cost of temporary relocation was calculated to be $394.7 thousand less than under the base condition. Table H-38 of the Economic Appendix shows average annual damage to roadways. Under the base condition, roadway damages were estimated at $27.9 thousand; the recommended plan would result in a reduction of those damages to $15.5 thousand.

55. Indian Camps Mitigation. Two villages occupied by members of the Miccosukee Tribe of Indians of Florida would be affected with implementation of the project.

a. Tiger Tail Indian Camp. The Miccosukee Indian Village, Tiger Tail Camp, is located north of U.S. 41 (Tamiami Trail) between the L-29 borrow canal and L-29, and between S-333 and S-334. Increased water levels as a result of project implementation would cause some flooding in the camp during most years. The Corps has discussed two options with the tribe; relocation of the camp or providing fill material to raise the ground and structure elevations at the present locations. The Indians have expressed a preference for having the camp raised. Based on this preference and the social impacts of relocating the camp, the recommended plan calls for raising the camp at its present location. Relocation of the camp to another location would be more costly than relocation in place.

b. Osceola Camp. A second Miccosukee village, Osceola Camp, is located on the south side of Tamiami Trail. Just of east of S-333, members of this village operate an airboat concession from the south side of the village into NESRS. With implementation of the project, water levels to the south of this camp would increase significantly. Conditions of the village south periphery and in the vicinity of the airboat launching area, are currently marginal during the wet season. Osceola members have expressed a preference for having their camp raised. Based on this preference and the social impacts of relocating, the recommended plan calls for raising the camp at its present location. As in the case of the Tiger Tail camp, relocation in place of the Osceola camp would cost less than relocation to another site.

56. L-67A Borrow Canal Boating Access. The entire 25.9 mile length of the Levee 67A borrow canal from its southern end at Tamiami Trail to the Everglades Holiday Park and S-9 at its northern end is utilized by recreational boating interests. The canal is a very important recreational resource for Broward and Dade Counties. Boaters launch their craft at both ends of the canal and currently have unrestricted access to its entire length. Boat ramps are located at Tamiami Trail and at Everglades Holiday Park. The S-349 structures would eliminate boating access to the middle portions of the L-67A borrow canal. This issue was raised during the public review/comment period for the draft GDM and EIS. The mitigation plan calls for adding a small boat bypass channel around each of the levees at the S-349 structures. Low speed navigation of the channels would be available in all but the most extreme drought conditions. The canal depth would be about three feet during low water conditions. The bottom width of the channels was set to allow single boat slow speed passage around the structure. Entry points to each channel would be at 300 feet upstream and 200 feet downstream of each proposed S-349 structure. The radius of the turn around the end of each levee was

designed to produce long sight lines which would allow ample time for maneuvering to avoid oncoming vessels. Boaters would be required to traverse the channels at idle speeds for safety reasons. More information about other plans considered for boating access to the L-67A borrow canal can be found in Section K of this report.

57. Structure 334 and Tamiami Trail. The East Coast Protection Levee (L-30 and L-31N) was one of the first project features constructed to prevent flood waters of the Everglades from spilling into the urban east coast areas. In the mid-1970's, S-334 was built and the Tamiami Trail bridge over the L-31N borrow canal was rebuilt in conjunction with the construction of the South Dade County Conveyance System. However, when these works were completed, the design grade of the East Coast Protection Levee was not maintained. The structure and the bridge over the L-31N borrow canal are low points in the levee and the higher stages in L-29 borrow canal that would occur under several of the proposed project alternatives would cause overtopping of the gates at S-334. Therefore, S-334 and a section of Tamiami Trail in the vicinity of L-31N must be modified to withstand the higher stages in the L-29 borrow canal.

58. Monitoring Measures.

a. Agricultural Area Monitoring. Agricultural flood damages begin before water levels rise above ground. When the water level rises into the root zone of many crops grown in the East Everglades, damages occur, whether through reduced productivity or total loss of the crop or plant. For example, lime trees cover more acreage in the East Everglades than any other crop. Typically the root depth of a lime tree is about 18 inches. According to local agricultural interests, subtle reductions in productivity will occur due to root zone inundation for durations of less than 24 hours. Root zone inundation for more than 48 hours duration can result in total fruit loss, and root zone inundation in excess of seven days can destroy the tree. Hydrologic modeling by the Corps indicated that the agricultural area would not be adversely affected by any of the proposed structural alternatives. PL 100-229 provides that this determination will be reviewed not later than 18 months after completion of construction of the proposed project. The monitoring will be done mostly by using existing monitoring wells in the area.

b. Snail Kite Monitoring. Snail kite habitat requires a comparatively long hydroperiod. Lengthening the hydroperiod in NESRS (to 2-6 years) could expand this habitat to benefit the kite and other members of the community. The Park Service is currently monitoring key indicator and endangered species in the Park and NESRS by conducting airboat surveys on a regular basis. Monitoring of the snail kite would be continued under the recommended plan to verify that the project does not adversely effect the species. Details on the proposed monitoring are contained in Appendix C of the EIS.

In conjunction with monitoring the snail kite in the NESRS area, monitoring vegetation and ecology in WCA No. 3 would be necessary. The key for developing the best possible water delivery operation for restoration of ENP, is a long-term program of monitoring plant and animal responses in the Everglades to changes in water management. Everglades National Park is

committed to such a program. Ecological information has been gathered in WCA No. 3 and Big Cypress National Preserve for the past five years through the Systematic Reconnaissance Flights study by the SFWMD and the Florida Game and Freshwater Fish Commission. Involvement of these agencies in data collection would be critical to assessment of project improvements.

c. Hydrologic Monitoring. In addition to the other monitoring measures, monitoring of WCA No. 3 would be necessary to seek possible correlation between hydroperiods and ecology. To supplement the existing gaging network, two more hydro-meteorological gages would be added to this area. Changes in hydroperiods may also affect a major airboat concession operated from the Miccosukee headquarters area. Trips are launched into WCA No. 3A from a location between S-12A and S-12B. These trips consist of a tour through natural Everglades habitats, and of native Miccosukee Indians practicing tribal crafts and lifestyles at villages on Everglades tree islands. Modifications to the hydrology in southern portion of WCA No. 3A, due to implementation of the project, could reduce the number of days in which airboat tours would be possible. In the last few years, droughts have severely curtailed airboat concessions during the dry season.

H. RECOMMENDED PROJECT

59. Selected Plan. The recommended project consists of the structural features included in the basic and modified rain-driven (MRD) alternative as developed during Phases 3 and 4 of plan formulation, Plan G for flood mitigation of the East Everglades area, raising the Osceola and Tiger Tail Indian Camps, relocation of S-334, modification to a portion of Tamiami Trail, monitoring of the East Everglades agricultural area, and monitoring of the endangered species, hydroperiods, and ecology of the area. A detailed description of the recommended project features is contained in Section J.

60. Rationale for Recommended Project. The reasons for recommending the proposed project may be characterized in terms of the three major categories of significance for environmental quality, as defined in the "Principles and Guidelines" (10 March 1983). These categories are: technical recognition, institutional recognition, and public recognition.

61. Technical Recognition. The technical category recognizes the actual technical and scientific accomplishments of the recommended project in terms of what its likely effects are expected to be. The recommended project will create hydrologic conditions that will favorably affect the unique ecological resources of Everglades National Park. The goal of restoring natural hydrologic conditions will be met in terms of all three of its dimensions: location, timing and volume (see Figure 2):

* Location - The historic path of Shark River Slough will be restored by bringing WCA No. 3B and NESRS back into the flow-way between WCA No. 3A and Everglades National Park.

* Timing - Water flows through the restored Shark River Slough will reflect natural local meteorological conditions, including the extremes of natural droughts and floods, and variations in the annual seasonal and long-term cycles.

* Volume - The volume of water delivered will reflect the naturally available supplies based on local meteorological conditions, except in cases where operations of the C&SF project for other authorized project purposes necessitate increased or decreased deliveries. Natural hydroperiods will be restored.

Restoration of natural hydrologic conditions will have a variety of beneficial, cumulative effects on the Everglades ecosystem. While detailed or quantitative estimates of these effects are constrained by our limited understanding of the many complex, interrelated ecosystem processes and resources that comprise the Everglades, general descriptions of the likely effects of the recommended project on major ecosystem components, which are summarized in Table 3, are as follows:

a. Water Quality. Water quality at entrance points to Everglades National Park is expected to improve with the recommended project. Most notable should be a decrease in the nutrient concentrations in the lower sections of the L-67A borrow canal and a decrease in contaminated sediment transport in the L-67A borrow canal due to a decrease in the rate of flow. By diverting flow through the marsh, uptake of inorganic nutrients will occur and flow velocities will decrease, thus enabling suspended sediments to settle. Sodium, chloride, magnesium, color, and iron concentrations may decrease in waters flowing directly into the Park because of the diversion of water to WCA No. 3B, thus, providing a greater potential for dilution by sheet flow and rainfall.

b. Periphyton. The recommended project will ensure the protection of the Park's sensitive algal mat communities, the base of the Everglades food web, by reversing the trend of increasing nutrient loadings to the Park. The project will also redistribute water over a much broader area of the Park, thereby lengthening hydroperiods, increasing the areal coverage of periphyton communities, and improving the overall productivity of the ecosystem.

c. Vegetation. Restoration of flow and hydroperiods to NESRS will increase the density of sawgrass in marl prairies and sawgrass marshes. Fire effects should be reversed, with succession toward more natural communities rather than weedy, early successional communities.

Removal of the L-67 Extension Levee and borrow canal will decrease the movement of nutrient-laden water into the marshes and the subsequent invasion of cattails. Peak stages would be reduced during flood releases, thereby curtailing hardwood mortality.

A decrease in management-exaggerated flooding within the Park will reduce mortality of hardwoods in and around tree islands. Sawgrass decadence would be less common, occurring only in response to natural events.

Restoration of the natural location and timing of water distribution into the marshes and prairies of the southern Everglades in and around the Park will create the conditions necessary for optimum primary production, nutrient cycling, organic soil formation, and energy flow through the Everglades wetland vegetation communities.

The re-establishment of natural marsh communities by more favorable hydrologic conditions will reduce the spread of exotic plants. Increased depths and more natural hydroperiods in NESRS will make communities there less susceptible to invasion by *Melaleuca*, thereby containing seed rain outside the Park. Filling the L-67 Extension borrow canal will reduce the chance of introduction of water hyacinths or other aquatic weeds deep into the Park. Removal of the L-67 Levee will eliminate high ground occupied by exotic tree species which release seeds into adjacent marshes.

d. Fisheries. An increase in hydroperiods in peripheral marshes and the marshes of NESRS will maintain fluctuating water conditions in the slough basin, providing residual pools in the central slough as refuges and sources of fish to recolonize flooded marshes in the wet season. Improvements in fish populations will make them more available to predators, such as wading birds.

e. Wading Birds. The strongest benefit for wading birds in Everglades National Park will be derived from a greater flexibility in water management options available with the recommended plan for both the Park and NESRS. Lengthened annual hydroperiods and substantially increased areas of flooding, along with a pattern of high summer water level and adequate winter drying rates throughout the marshes, are the hydrologic events most likely to improve overall feeding conditions for wading birds in the Park. This would be especially true in marshes peripheral to the central Shark River Slough and east of the Park boundary. By increasing water in NESRS, marshes along the slough's edge will have increased hydroperiods leading to increased animal biomass. This change should provide the wading birds that feed and nest in the Park with better foraging conditions over a longer time period than presently exists.

Stabilization of the deteriorating wood stork population and return of the smaller waders to nesting in the traditional southern Shark River Slough colony sites is distinctly possible. The Park will probably never again support the number of storks and other waders that nested there in the 1930's and 1940's, or even that nested there in the early 1960's. However, populations of storks and the smaller waders comparable in size to those of the early and mid-1970's, ranging between 750-1,000 pair of wood storks, can be reestablished given greater revitalization of a large area of southern Everglades marshes and a better understanding of relationships between water delivery and impacts on bird feeding habitats.

f. Alligators. The recommended plan will permit the flexibility necessary to more effectively control drydown from the wet to dry seasons (minimizing reversals or dry season flooding), and permit the correlation of early summer and maximum surface water levels. Delivery of water into Shark River Slough, including NESRS, will allow the alligators' range to expand, which could prove beneficial to many species, from plant communities, invertebrates (such as crayfish and snails), fishes, turtles and wading birds, that are so closely linked to the ecology of the alligator.

g. Fire. The return of more natural hydrologic conditions will reduce the probability of the occurrence of destructive peat (ground) fires by reducing the time during the dry season when the moisture content of surface peat is at ignition conditions.

62. Institutional Recognition. The institutional category recognizes the ways in which the recommended project fulfills the intent of various laws, adopted plans, and other policy statements of public agencies and private groups. Tables 13 and 14 present evaluations of the relationships of the recommended project with key Federal policies and plans of other agencies, respectively.

The recommended project will significantly improve the long-term ecological conditions in Everglades National Park, thereby fulfilling the specific and broad intents of several national mandates, in particular:

* Everglades National Park Protection and Expansion Act of 1989, which states that one of its purposes is to, "increase the level of protection of the outstanding natural values of the Everglades National Park and to Enhance and restore the ecological values, natural hydrologic conditions, and public enjoyment of such area".

* National Environmental Policy Act of 1969, as amended, which requires the Federal government to "improve Federal plans... [to] preserve important historic, cultural and natural aspects of our national heritage".

* Endangered Species Act of 1973, as amended, which charges Federal agencies to use their authorities to carry out "programs for the conservation of endangered species and threatened species".

* Fish and Wildlife Coordination Act, as amended, which states that, "wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation".

63. Public Recognition. The public category recognizes the views of Federal, State and local public agencies, private groups, individuals, and others concerning the recommended plan and its effects on the ecology of Everglades National Park. The views that various agencies and groups have expressed to date are summarized in Table 13.

The Corps of Engineers has been working very closely, for many years, with the South Florida Water Management District, the project sponsor, the National Parks Service (Everglades National Park), which is responsible for the park resource to be benefitted by the project, and the Fish and Wildlife Service, which is the advocate for the nation's wildlife resources. All of these agencies support modifications to the structures and operational procedures of the Central and Southern Florida Project to improve deliveries of water to the Park. The Corps will continue to work with these key project partners to ensure that project implementation will produce the desired improvements in the Park's ecology.

Distribution of the draft General Design Memorandum to the public, produced comments with different views and suggestions about the recommended project, and provided for the public recognition category as a basis for project selection. Comments can be found in the coordination section of the EIS.

I. INCREMENTAL ENVIRONMENTAL ANALYSIS

64. First Increment: Construction of residential mitigation features, flood-protection of Tiger Tail Camp, relocation of S-334, and implementation of the best possible water control plan for the C&SF project.

Under normal water conditions without any regulatory flood releases from WCA No. 3A, S-333 has sufficient discharge capacity to convey into the L-29 borrow canal the targeted 55 percent of calculated water volumes for delivery across the Tamiami Trail into the Park. From the canal, the water flows into NESRS through the 53 existing sets of culverts under the Tamiami Trail. Under flood conditions when releases (usually regulatory) in excess of 2300 cfs need to be made from WCA No. 3A, the discharge capacity of S-333 would not be sufficient to pass the full 55 percent targeted for NESRS. The chimney of the Park would then get more than the targeted 45 percent of the water delivery, resulting in unnaturally high water stages relative to the rest of the slough. This would contribute to the condition that has been seen in the field in which water entrained south along L-67 Ext. moves quickly eastward and sometimes northward after it passes the south end of the levee. This creates a mound of water in the southern end of NESRS that sets up a steep gradient of groundwater flow in the direction of the East Everglades agricultural area. There is a potential that this would increase the risk of flooding in that area because, compared with the recommended plan, a larger volume of water would be moving in that direction from a more southern location. The umbrella effect from the residential levees might not fully prevent flood damages in the agricultural area. The reduced volume of water that could be discharged into NESRS during wet season storms would curtail the eastern-most spread of water up the slope of the basin under some conditions, thereby shortening hydroperiods.

Under the features of the first increment, there would be a considerable increase in the amount of water entering NESRS over the Base Condition. This would begin the restoration process in a portion of the area. However, the unnatural hydrologic conditions described above would produce distorted hydropatterns in NESRS that would severely limit the degree of restoration of wildlife populations. No hydrological or ecological restoration would occur in the 100,000 acres of Everglades habitat in WCA No. 3B. It would continue to be a relatively shallow impoundment with little fluctuation in water levels. This would continue the regional loss of seasonal habitat diversity that was an important aspect of the historical Everglades. The high marsh along the eastern slope of the Everglades Basin in NESRS and WCA No. 3B would continue to suffer lowered primary and secondary productivity from truncated hydroperiods. Wading bird populations would continue to suffer unnaturally high reproductive failure rates caused by an inadequate and inaccessible food base during the nesting season. Alligators would not repopulate NESRS at historic levels, and the continued lower number of gator holes would contribute to incomplete ecological restoration. Alligators within the chimney would continue to suffer from occasional nest flooding. The unnatural confinement of the deepest water of the basin during the wet season in the western portion would reduce the extent and duration of recharge of the Biscayne Aquifer and continue the reduction of the historical hydrologic connection between the Shark River Slough Basin, Taylor Slough, and the

eastern panhandle of the Park. Under these conditions of truncated surface water and groundwater flow, the Park's estuarine areas, particularly Florida Bay, would continue to suffer reduced productivity from unnaturally frequent and extensive episodes of hypersalinity and/or reduced nutrient exchange. There could be limited recovery of coastal populations of wading birds, fish-eating raptors, pelicans, and sportfish in northeast Florida Bay, but the full potential recovery could not be realized.

65. Second Increment: Removal of the L-67 Extension and borrow canal and implementation of the best possible operation of the C&SF project.

The removal of the levee and canal bisecting the northern 10 miles of Shark River Slough would allow water deliveries discharged through the S-12 structures to spread southeast by gravity flow following the marsh topography. This would fully restore the hydrologic connection between the chimney and NESRS, and remove the threat of flooding in the East Everglades agricultural area. However, the limiting capacity of S-333 for spreading regulatory flood releases directly into NESRS would still present an impediment to restoration of natural water conditions in the Park. The eastern slope of the Everglades Basin in NESRS would still have shortened hydroperiods resulting in lower than historic primary and secondary productivity. Ecological restoration in the expanded Park would be intermediate between the first increment and the recommended plan (increments one through three). Alligator nest-flooding south of the S-12's (former chimney) would be reduced in frequency, and the population would expand more into NESRS, its historic center of density. As in the first increment, WCA No. 3B would not have been brought back into the Everglades system. The lack of maximum opportunity to use the potential productivity from this 100,000 acres of Everglades habitat would still severely limit the ability of wading birds to make a reproductive recovery. Historically, WCA No. 3B was a very important dry season feeding habitat for wading birds in the large nesting colonies in the Park. The periphyton-forage fish-wading bird food chain has virtually collapsed in this area since it has been impounded. Aquifer recharge and restoration of groundwater and surface water flows to tidewater would be proportional to the higher water levels reached in the eastern portion of SRS during the peak of the wet season. This also relates to the degree of estuarine recovery.

66. Third Increment: Construction of features to divert water from WCA No. 3A through WCA No. 3B into NESRS, and implementation of the best possible water control plan of the C&SF project. An equally important aspect for implementing the last increment is the acquisition of lands in the NESRS area. Until the land acquisition is complete water deliveries to NESRS would be restricted and would be similar in magnitude to those under the experimental program. Unless the experimental program is authorized beyond 1 January 1992, water deliveries to ENP will be reverted to the minimum delivery schedule authorized in PL 91-282.

Conveyance of water from WCA No. 3A through WCA No. 3B would restore the historic flow patterns in the Everglades Basin. By so doing, 100,000 acres of prime Everglades habitat would be brought back as a fully functional component of the Everglades system. The surface water component added to direct rainfall effects in WCA No. 3B would recreate the hydrologic dynamics

in the system that has been almost totally lost since the area was impounded. The additional volume would create a fluctuating water level with seasonally deeper water in the center of the historic slough in WCA No. 3B, and would restore the historic short hydroperiod in the marshes along the eastern edge. This would build up the food resource base of small fishes and macro-invertebrates for harvesting by wading birds during the dry season recession. The increased water levels and secondary productivity combined with the topographical heterogeneity of the area would create a seasonal diversity of feeding habitats. This would greatly increase the opportunities for wading birds to find forage sites under a wide range of water conditions. Ecological restoration of WCA No. 3B is believed to be the key to restoring long-term trends in successful nesting by wood storks and other wading birds in the Park because it historically played such an important role in sustaining the large nesting colonies during the dry season. Increased water depths would also benefit the apple snail, a food resource for a wide array of animals, and the essential food source for the snail kite. Regional snail kite populations, therefore, would be expected to increase as the kites repopulated the area.

Hydrologic restoration of WCA No. 3B is also essential to restoring natural water conditions in the Park. Diversion of flood waters from WCA No. 3A into detention in WCA No. 3B would decrease the volume of and, in some cases, the need for regulatory water releases into the Park from WCA No. 3A. This would reduce the frequency of unnatural distributions of water across SRS, and further reduce the occurrences of alligator nest flooding south of the S-12's. The ability to discharge an additional 2,000 cfs of water into NESRS through the new S-355 structures and 1,300 cfs through S-333, would allow full restoration of historic water depths in the center of the slough, thereby causing reflooding of the short-hydroperiod marshes on the eastern slope of the slough. This would accrue all the wildlife benefits from increased primary and secondary productivity previously discussed. In addition, aquifer recharge, reestablishment of groundwater flows, surface water reconnection between SRS and Taylor slough, and restoration of estuarine productivity would be maximized.

J. FEATURES OF RECOMMENDED PLAN

67. Description. The recommended plan consists of a Rain-Driven Water Delivery schedule and several structural modifications to the C&SF project. The proposed schedule would provide a more natural delivery that would closely simulate historic seasonal flows. The proposed modifications will allow a greater degree of operational flexibility for future water deliveries to ENP than the minimum delivery schedule prescribed by PL 91-282. The proposed modifications will allow an array of operating criteria from the Basic Rain-Driven to the Modified Rain-Driven and other rain-driven operating features. Water Conservation Area No. 3B would become an integral part of the delivery system, and timing, volume, and location of water deliveries would be modified through implementation of the proposed structural modifications. Integration of WCA No. 3B and expansion of ENP would accomplish one of the major objectives of the proposed project, which is restoration of historic flow patterns across the full width of Shark River Slough. Re-establishment of the historic flow-way would be the initial step to restoration of the ENP ecosystem. Timing and volumes, the other two major objectives, would be accomplished through evaluation of a continued iterative process similar to the currently authorized Experimental Program. An important aspect for restoring historic volumes to NESRS is the acquisition of lands in the area by the Department of the Interior. Without a timely land acquisition, water deliveries to NESRS would be curtailed, and would be similar in volume to the experimental program. The restoration process of ENP also would be delayed.

The iterative process will include hydrologic modeling and coordination to develop an acceptable water control plan. The process will be conducted concurrently with detailed engineering and design studies and construction of the project's structural features. The operational studies will consist of hydrologic modeling, coordination of modeling results, and environmental evaluations. This process will include re-initiation of endangered species consultation and preparation of a supplement to the Environmental Impact Statement (EIS) or an Environmental Assessment and Finding Of No Significant Impact (FONSI) as appropriate.

If an acceptable operational strategy has not been developed at the end of the iterative process, the Modified Rain-Driven Operational strategy addressed in this report will be the water control plan implemented when construction of the structural features is complete. Regardless of which water control plan is initially adopted, review and adjustment of project operations will continue as experience and additional assessment of data reveal potential for improvement.

The proposed structural modifications include S-345A, B and C; S-349A, B and C; S-355A and B; S-334 modification, removal of L-67 Extension and borrow canal filling; and a levee and canal system for flood mitigation in the developed East Everglades area. The levee and canal system includes two pumping stations, S-356 and S-357. The recommended plan would provide a system of water deliveries to ENP across the full width of the historic Shark River Slough flow way. Flow rates from the delivery system would fluctuate based upon local hydrometeorologic conditions. WCA No. 3B would be restored

as a hydrological component of the Everglades system that would interact directly with WCA No. 3A, the East Everglades, and ENP. There would be no adverse impacts to adjacent developed areas as a result of the recommended plan. The proposed plan of improvements are shown on Plate 17. A summary of total estimated first costs to implement the proposed modifications within this section are shown on Table 18.

a. Water Deliveries to ENP. A rain-driven delivery formula would be used to compute weekly rates of flow for discharges to ENP. The timing and rate of water deliveries would be composed of a rainfall-response component and a WCA No. 3A regulatory component. The sum of these two components would be the computed flow for delivery to Shark River Slough. The rainfall-response component would be computed using weekly total rainfall excess depths for the current week and nine previous weeks. The regulatory component would be based on the three station average in WCA No. 3A and would maintain the flood control capabilities in the area. Computed Shark River Slough water deliveries would be split between the S-12 and the S-355 structures supplemented by S-333, when necessary. The existing S-333 spillway would play an important role in supplementing S-355 discharges during the wet season and in transferring water supply during the dry season. The goal of the proposed delivery system would be for 55 percent of the total to be discharged through the S-355 spillways whenever possible, and the remaining 45 percent to be delivered at S-12. This ratio may revised if necessary when more data becomes available. The rainfall response and the regulatory components are described below.

(1) Rainfall-Response Component. Future refinement of the rainfall response component would be initiated by any of the parties to an agreement between the SFWMD, ENP, and the Corps. Weekly historical means of rainfall, evaporation, and total flow across Tamiami Trail for the period from 1941 through 1952 were used in the development of the following equation.

$$QRES = QM + (CQ \times QL) + (CR1 \times RE12) + (CR2 \times RE36) + (CR3 \times RE710)$$

where

QRES = computed rainfall response component based on the regression equation in cubic feet per second.

QM = mean discharge for current week

QL = deviation from mean discharge for previous week

RE12, RE36, RE710 = deviation of actual rainfall from mean historical rainfall minus 80 percent of the deviation from mean evaporation for previous two weeks, previous 3 to 6 weeks, and previous 7 to 10 weeks, respectively.

CQ = flow coefficient

CR1, CR2, CR3 = rainfall excess coefficients

The rainfall excess coefficients would be varied depending on whether the rainfall excess terms are positive or negative, as shown next.

Rainfall Coefficients

	Negative Rainfall Excess Term	Positive Rainfall Excess Term
CR1	52.22	70.58
CR2	0	9.49
CR3	0	9.18

(2) WCA No. 3A Regulatory Component. When the water level in WCA No. 3A rises above Zone E (see Plate 16), a supplemental regulatory component would be added to the rainfall response component. The regulatory component would be computed by multiplying the distance (in feet) the WCA No. 3A water level is above Zone E by 2,500 cfs.

(3) Structure Operations. Operations of specific structures would be prescribed by the proposed WCA No. 3A regulation schedule and the description of initial operations for rain-driven water deliveries described in Plate 16 and Figure 10, respectively.

68. Structures. Structural design and analysis of all structural features of this project will be in accordance with appropriate Corps of Engineers guidance and criteria. The design memoranda (to be prepared in the future) containing results of the detailed structural analysis will cite all relevant structural design criteria and guidance.

a. S-345 (A, B, and C). These three proposed gated culvert structures are identical in size and design. Each structure would consist of three 72-inch corrugated metal or concrete pipes with manually operated slide gates. A timber walkway and platform would be provided for access to the gate hoists. Hydraulic design data for these structures are given in Table 47. The estimated contract prices are given in Tables 19 through 22. Continuity of the existing levee system would be maintained during construction by providing a temporary levee tie-back system around the easterly side of the construction sites prior to breaching the existing levee. A typical section of the structures is shown on Plate 18. The proposed gated culvert structures in L-67A would enable discharges from WCA No. 3A into WCA No. 3B. The culvert structures would provide an alternative means of discharging regulatory releases from WCA No. 3A and to assist in restoring WCA No. 3B as a hydrologic component of the Everglades. Each structure would have a discharge capacity of 500 cfs. The structures would be located at approximately 20,000 feet apart in the central portion of L-67A between S-151 and S-333. A discharge channel would be constructed for each structure from L-67A through L-67C, and 500 feet into WCA No. 3B. The discharge channels would have a containment levee on each side between L-67A and L-67C. The discharge channels and containment levees would increase the hydraulic capacity for discharging water from WCA No. 3A into WCA No. 3B.

A three station average stage within WCA No. 3A would be used to operate the S-345 structures. Discharges begin when the stage rises to 0.5 feet below Zone C of the WCA No. 3A regulation schedule or when the stage enters Zone D. The discharges are linearly increased up to the structure capacity of 1,500 cfs when the stage reaches or exceeds Zone B or C. As the stage recedes, the discharges are reduced in the same manner.

b. S-349 (A, B, and C). These three proposed gated concrete headwall water control structures are identical in size and design. Each structure would consist of a reinforced concrete headwall and operating platform with four 10-foot-high by 12-foot-wide slide gates and steel pile tie-back walls. The gates would be operated by the use of a portable power unit. Access to the operating platform would be from existing Levee 67A along the proposed tie-back levee. Hydraulic design data for these structures is given in Table 48. The estimated contract prices are given in Tables 23 through 26. A typical section and elevation of the structures are shown on Plate 19. These water control structures would be constructed in the L-67A borrow canal.

Each of the S-349 structures would be located immediately south of each of the S-345 structures. The purpose of S-349 structures would be to reduce southward canal flow through WCA No. 3A; thereby inducing overland flow through the marsh and providing a more natural distribution of water in the area. During the wet season more water would be held in the northern marshes of WCA No. 3A. The structures would also produce higher water levels upstream of each of the S-345 structures thus increasing the discharge capacity into WCA No. 3B. For water supply demands in the ENP-South Dade County Conveyance System, the structures would be opened and water supply deliveries could be passed down the L-67A borrow canal to S-333. Each of the structures would have a discharge capacity of 1,250 cfs under low water conditions which is similar to the L-67A borrow canal capacity. During normal or wet periods, the structures would remain mostly closed, however, they would be operated when needed.

c. S-355 (A and B). These two proposed spillway structures are identical in size and design. Each structure would be a two-bay, reinforced concrete, U-shaped, gated (vertical lift gates) ogee weir-type spillway. These spillway structures would discharge water from WCA No. 3B into existing Levee 29 borrow canal (Tamiami Canal). Continuity of the existing levee system would be maintained during construction by providing a temporary levee tie-back system around the north side of the construction sites prior to breaching the existing levee. Hydraulic design data for these structures is given in Table 49. The estimated contract prices are given in Tables 27 through 29. A typical section of the structures is shown on Plate 20. These proposed gated spillway structures would be spaced about 12,400 feet apart in L-29 midway between S-333 and S-334. S-355 would serve as an outlet for water releases from WCA No. 3B and enable the delivery of water from WCA No. 3B into NESRS. Together with the S-345 structures, these structures would hydrologically reconnect WCA No. 3B to the remainder of the adjacent Everglades areas. S-355A and B would be used as the first priority for discharging water deliveries to NESRS. Each structure would have a discharge capacity of 1,000 cfs with 0.3 feet of head. Also, each structure would be constructed to allow L-29 east-west vehicular traffic, particularly the

Miccosukee Tribe, access across the spillway bridge. One-thousand (1,000) foot long collection canals would be constructed in WCA No. 3B running east-west just upstream of each structure. Each canal would collect marsh flow through WCA No. 3B and facilitate the discharge of water into NESRS. Discharges through the S-355 structures would be adjusted weekly to pass 55 percent of the total computed water delivery to Shark River Slough. When S-355 discharge capacity is not adequate to pass the desired 55 percent to NESRS, S-333 would be used to supplement the flows, as necessary. When there is no head or a reverse head across S-355, all structures would remain closed.

d. S-334 and Tamiami Trail Modifications. S-334 is an existing one-bay (29-foot bay width), reinforced concrete, U-shaped, trapezoidal weir-type, gated spillway. The spillway is located in Levee 29 borrow canal approximately 1,500 feet west of the junction with Levee 30 borrow canal. The protection elevation of the existing spillway is 14.0 feet, NGVD. It is proposed to raise the protection elevation to 17.4 feet, NGVD. This will increase the headwater elevation during an SPF condition to El. 14.5 from El. 8.5. The SPF tailwater elevation will remain at El. 5.0. The net head differential at S-334 will, therefore, increase from 3.5 feet to 9.5 feet. It is proposed that S-334 be replaced with a new spillway structure which will tie Levee 30 and Levee 31N together providing protection at the same elevation. It is not considered feasible to modify the existing structure to withstand the additional hydrostatic forces of this magnitude. The proposed spillway is shown on Plate 21.

It would be necessary to raise the elevation of U.S. 41 from 10.6 to 17.4 for a short distance and ramp up to and down from that elevation to existing road grade. A tie-back levee from U.S. 41 to Levee 31N would also be required. During construction, the existing structure would be closed down (no discharges made). Should additional water supply downstream of the structure be required during construction, increased discharges could be made through S-335. Hydraulic design date for the modification of S-334 is given in Table 50. The estimated contract price is given in Tables 30 and 31.

In order to pass the desired volumes of water through the culverts under Tamiami Trail (U.S. 41), the L-29 borrow canal stages could rise to nearly 10.0 feet, NGVD, occasionally. L-31N will be tied into Tamiami Trail just west of the bridge over the borrow canal, the adjacent section of road will be raised to restore the design grade of 17.4 feet, NGVD, and L-31N will then be tied into L-30 at S-334. The protection elevation of L-29 from S-334 to L-30 would also be raised from 14.0 to 17.4 feet, NGVD.

(1) Tamiami Trail. The road grade of U.S. 41 would be elevated from 10.6 to 17.4 feet, NGVD, for a short distance (150 feet) adjacent to S-334 and transition up and down from that elevation to the existing road grade. This transition would ideally conform to the highway design parameters for minimum sight distances. Geometric design for this change in grade based on sag and crest curves indicate nearly 1,500 feet of highway on each side of S-334 (3,000 feet total) would have to be raised or modified. A temporary bypass road and embankment would be built approximately 150 feet south of U.S. 41 to allow traffic passage around the 3,000 feet of construction. A tie-back levee starting at U.S. 41 and continuing south for a short distance before turning

east and extending to L-31N at elevation 17.4 feet, NGVD, would also be required. Quantities and cost estimates for the road modification project are presented in Tables 32 and 33.

69. Canals.

a. S-345 Discharge Canals. A 7,200 foot length by 30 foot bottom width discharge canal would be constructed for each of the S-345 structures starting at L-67A and extending through L-67C into WCA No. 3B. The purpose of the canals is to allow conveyance of water from WCA No. 3A into WCA No. 3B with a minimum energy loss. Adjacent tie-back levees on each side of the canal would extend from L-67A to L-67C (a length of 6,200 feet). Beyond L-67C, the canal would gradually transition from its design invert to existing ground over a distance of approximately 1,000 feet. A short intake canal would also be provided to route flow from the L-67A borrow canal to the culvert structure itself located in L-67A. At the eastern end of the canal, it would be necessary to gap L-67C and fill-in a portion of the existing borrow canal to enable construction of the discharge canal and levees. Approximately 50 percent of the material necessary to construct the tie-back levees would be obtained from the canal excavation; the remainder of the material would be purchased from commercial borrow sites near Miami. About 40 percent of the canal excavation would be in rock and blasting would likely be required. Conventional earth moving equipment including draglines, front-end loaders and bulldozers would be suitable for the canal and levee construction. A typical site plan for the S-345 canals and levees is shown in Plate 22. Quantities and cost estimates for the S-345 structures and associated works are indicated in Tables 19 through 22.

b. S-349 Bypass Canals. A bypass canal would be constructed around each of the S-349 structures and its associated interceptor levee to enable recreational boaters continued navigational passage along the Levee 67A borrow canal. The bypass canal would enter and exit the Levee 67A borrow canal approximately 300 feet on either side of the S-349 before turning to run closely adjacent to both sides of the 1000 foot interceptor levee producing a total length of about 2700 feet. The canal would be constructed with a 24 foot bottom width at a design invert of elevation +4.0 ft. in order to provide adequate channel width and depth for the anticipated two-way vessel traffic. Since the rock layer is at or near the surface in this area, some blasting may be necessary to obtain the required canal excavation. Suitable material obtained from the excavation would be used to construct the interceptor levee. Channel bends in the bypass canal would be constructed to a minimum radius of 5 times the design vessel length or about 85 feet. However, the visual obstruction of the interceptor levee between the parallel canal reaches make it imperative that additional measures (i.e., sign posting of speed limits, turns, narrow passages) be provided to further enhance navigational safety along the canal. A typical cross-section of the bypass canal is shown in Plate 25.

c. S-355 Collection Canal. Two (2) 1,000 foot length by 60 foot bottom width canals would be constructed just north and parallel to existing L-29 to collect overland flows from Water Conservation Area 3B and distribute them to both S-355 structures. Intake and discharge canals would also be constructed

on each side of the S-355 structures allowing water from the collector canals to flow through the spillways and be discharged into the existing L-29 borrow canal. Excavation of the canals would be 30 percent in rock and blasting would be necessary for economical removal. The excavated material would likely be used both in the S-355 construction and levee modification as well as other nearby project features along L-29, including the fill raising of the Miccosukee Indian village (Tigertail Camp) and levee construction associated with the proposed S-334 and S-356 works. Excess or unsuitable material would be placed along the northern slope of the adjacent Levee 29. Plate 23 shows a general plan view of the S-355 canals and Tables 27 through 29 provides the applicable quantities and cost estimates.

d. Intake/Discharge Canals for S-356. An intake and discharge canal (each approximately 700 foot length by 77 foot bottom width) would be provided to convey Levee 29 borrow canal flows to and from the S-356 pump station. The canals would be constructed on a minimum 435 foot radius arc with transitions to straight sections for final tie-in with the pump station. Excavation of the canals (design invert of -7.0 feet, NGVD, with 2H:1V side slopes) would be nearly 60 percent in rock with blasting likely required. The suitable excavated material would be used in the relocation and enlargement of Levee 29 around S-356, as well as the tie-back levee to S-334 at 17.4 feet, NGVD. Unsuitable material would be used to plate the levees or else disposed nearby along the northern slope of existing Levee 29. Plate 24 shows a general plan of S-356 (including the canals) and Tables 34 and 35 gives the quantities and cost estimates.

e. Flood Control Canals. A canal system would be provided within the developed East Everglades as part of the levee and canal system for the residential portion of the East Everglades. Seepage collection canals would be provided about 600 feet inside the outer protection levees. The canals would vary in size from a V-ditch (6 foot deep) to a 40 foot bottom width canal 13 foot deep. These canals would collect and convey seepage waters and some local runoff (or groundwater inflow) to pump station S-357 where it would be pumped into the L-31N borrow canal. A short section of discharge canal immediately downstream of S-357 would be lined with concrete to prevent return seepage to the upstream canal when S-357 is pumping.

70. Levees.

a. S-345 Containment Levees. These levees would be located on each side of the S-345 discharge canals from L-67A to L-67C. The purpose of the levees would be to hold S-345 discharges within the canal for conveyance into WCA No. 3B and to prevent water from spreading into the area between L-67A and L-67C.

b. Interceptor Levee for S-349 Structures. A small levee, starting at each S-349 structure and extending approximately 1,000 feet westward, would be constructed in order to intercept and divert overland flows from Water Conservation Area No. 3A. The flows would be directed by the levee towards the S-349 and S-345 structures where they would control discharges to Water Conservation Area No. 3B. Material excavated from the adjacent bypass canals

would be used to construct the relatively small (6.5 foot height) levees. Plate 25 depicts the general plan view of the levees. Quantities and cost estimates for the levees are included as part of the S-349 estimate in Tables 23 through 26.

c. Tie-back Levees for S-334. In conjunction with modifying S-334 to raise its protection elevation, short levees must be provided from the structure to tie into L-30 to the north and to tie into L-31N to the south. These tie-back levees would be constructed to the same dimensions as the adjacent sections of L-30 and L-31N. The northern tie-back levee would be constructed to 18.0 feet, NGVD, and the southern tie-back levee would be constructed to 17.4 feet, NGVD. A short section of Tamiami Trail would also have to be raised to 17.4 feet, NGVD, where the tie-back levee crosses the highway.

d. Degradation of L-67 Extension. L-67 Extension would be degraded along its entire length to allow full hydrologic interaction between portions of the slough now separated by the levee. Starting at U.S. 41 and extending approximately 9.5 miles southward, an estimated 550,000 cubic yards of levee and berm material would be leveled to existing ground with conventional earth equipment. Disposal of the material would be in the continuous borrow pit adjacent to and west of the levee. Plans and cross-sections of the levee degradation work are shown in Plate 26. Quantities and cost estimates for the work are presented in Tables 36 and 37.

e. S-356 Levees. A portion of existing Levee 29 would be relocated to allow for placement of the proposed S-356 pump station. The relocated levee would generally follow the alinement of the S-356 intake/discharge canals and would be placed about 200 feet north of the canal alinement. Levee 29 would be constructed to 18.0 feet, NGVD, east of S-356 and 14.0 feet, NGVD, (same as existing) to the west of S-356. Tie-in with the existing Levee 29 alinement would be approximately 800 feet to either side of S-356. A short tie-back levee would also be constructed between S-334 and S-356 tieing in both structures at 17.4 feet, NGVD. This levee would also serve as a road embankment providing vehicular access from S-334 to S-356. Plate 24 shows a general plan of S-356 (including the levees) and Tables 34 and 35 gives the quantities and cost estimates.

f. Residential Area Seepage Levees. A levee system would be constructed to mitigate for increased flood risks to the East Everglades Residential Area resulting from increased water stages in the NESRS and ENP due to the project. The levees would start on the north side of the residential area at the junction with L-31N and extend along the northern and western perimeters of the area before terminating at Richmond Drive, a distance of approximately 7.5 miles. A double levee system would be utilized exclusively to reduce seepage into the residential area. The outer levee would be constructed to design elevations varying between +10.1 and +10.3 feet, NGVD. To maintain the minimum required seepage path of 63 feet beneath the levee, an impervious geotextile blanket system would be placed on the exterior face of the outer levee. The inner levee would be built approximately 300 feet interior of the outer levee at a constant design elevation of +9.5 feet, NGVD.

The material obtained from the residential area canal excavations would be compacted and used to build the levees. The small amount of peat encountered would be stockpiled and later used in plating the levees for grass propagation. About ninety-six percent (96 %) or 496,000 cubic yards of the estimated 519,000 cubic yards of required levee and berm material would be obtained from the seepage canal excavations; the remaining portion of levee material would be borrowed from an existing spoil bank east of the Levee 31N borrow canal. The spoil banks would not be degraded below a minimum 3.0 foot high berm in order to maintain their secondary function of reducing seepage eastward.

Construction quantities for the levees include a 1.0 foot overbuild above the design elevation to account for non-uniform ground surfaces and placement tolerances. The general plan and alinement for the residential area levee/canal system is indicated on Plate 22. Cross-sections for the levee/canal reaches are shown on Plates 28 through 32. Quantities and cost estimates for the residential works are presented in Tables 38 and 39.

The possibility of constructing a single levee, structural floodwalls, and other structural options instead of the above mentioned levee system will be examined and presented in the Feature Design Memorandum (FDM).

g. Flood Mitigation. The residential area in the East Everglades and two Miccosukee Indian villages, Tigertail Camp and Osceola Camp, are expected to be impacted by elevated water levels from the ENP project and, thus, will require mitigation measures.

(1) Residential Area. The lands, easements, rights-of-way and relocations needed to implement the residential protection features of the will be acquired and performed under this plan. The total estimated cost for implementing the project features in the residential area is approximately $24,574,000 (see Tables 38 and 44). For further description of lands acquisition see the Real Estate Design memorandum.

(2) Tigertail Camp. The camp is situated on the berm strip formed between L-29 and L-29 borrow canal and is located about five (5) miles west of existing L-30 and S-334. Approximately 24 individuals and an assortment of 15 structures (ranging from traditional thatched roof chickees to inexpensively constructed frame houses) comprise the village occupying an area of about 1 acre. Since the existing grade of the village is about 7.5 feet, NGVD, and the maximum stages in the L-29 borrow canal are expected to reach 9.5 feet, NGVD, as a result of the project, a mitigation plan is proposed to prevent flooding of the village.

The plan involves salvaging and/or demolishing the existing camp structures, relocating the villagers to temporary on-site housing, elevating the village site with approximately three (3) feet of fill and lastly, supplying the village with comparable replacement structures. However, the reconstruction of the camp would be in accordance with Decent Safe and Sanitary Housing Standards (i.e., HUD, Uniform Building Code and local codes where applicable) and would, in general, represent an improvement over existing conditions both in terms of quality of structures and in the

provision of certain utilities currently not found in the village. Utility provisions would include electrics, pressured water supply, bathing and sewage systems for each living quarters. It is proposed that the existing framed living quarters be replaced with four (4) single-wide (60 feet by 12 feet each) and two (2) double-wide (60 feet by 24 feet each) mobile homes providing a total living area of 5,760 square feet. Some exceptions to the building code are anticipated since the traditional and modified chickee structures would need to be reconstructed in their original fashion to maintain certain cultural heritages. A general site plan of the village is shown in Plate 33. Quantities and cost estimates for the village mitigation plan are presented in Tables 40 and 41.

(3) Osceola Camp. This small camp is located just south of U.S. 41, about 10.5 miles west of L-30 and S-334. Occupying about 1-1/2 acres the camp is comprised mostly of traditional chickee and modified chickee structures housing five (5) inhabitants. Since the average existing grade of the village is about 8 feet, NGVD, a mitigation plan is proposed to prevent flooding of the village when the project resultant stages approach their maximum elevation of 9.5 feet, NGVD. Although the camp resides on lands intended for Department of Interior purchase as part of the ENP expansion, it appears that the Corps of Engineers will be selected as the Federal agency responsible for developing a mitigation plan for Osceola Camp.

Similar to the Tiger Tail Camp treatment, the plan involves salvaging and/or demolishing the existing camp structures, relocating the villagers to temporary on-site housing, elevating the village site with fill material to elevation 10.5 feet, NGVD, and lastly, supplying the village with comparable replacement structures. Reconstruction of the camp would be in accordance with Decent Safe and Sanitary Housing Standards (i.e., HUD, Uniform Building Code and local codes where applicable) and would, in general, represent an improvement over existing conditions both in terms of quality of structures and in the provision of certain utilities currently not found in the village. Utility provisions would include electrics, pressured water supply, bathing and sewage systems for each living quarters. Some exceptions to the building code are anticipated since the traditional and modified chickee structures would need to be reconstructed in their original fashion to maintain certain cultural heritages. A general site plan of the village is shown in Plate 34. Quantities and cost estimates for the village mitigation plan are presented in Tables 42 and 43.

(4) Levee 29 Recreation Area. An existing 2.5 acre (1,100 foot long by 110 foot wide) recreation site located on the Levee 29 berm about 2.8 miles west of S-334 would be impacted intermittently as a result of the elevated project stages in the Levee 29 borrow canal. The site consists of six (6) picnic table shelters, several native tree species and a small public boat ramp. The site would experience minor ground flooding when the Levee 29 stages exceed 8.5 feet, NGVD, which is predicted to occur only 10 percent of the time, or about 37 days a year. Due to the limited project impacts both in terms of duration and potential damages, it is recommended that no mitigation plan be enacted for the recreation site.

71. Pump Stations.

a. S-356. This pump station would have a capacity of 950 cfs to pump excess water from L-31N borrow canal into the L-29 borrow canal. The pump station would be located in parallel with S-334. It would provide a means of controlling additional inflows to L-31N borrow canal caused by increased seepage into the canal and pumping flood waters from the protected residential area in the East Everglades. The structure would consist of a mass and reinforced concrete substructure and a superstructure of concrete block walls and reinforced concrete columns. The pumping station would have three pumping bays each containing an identical axial-flow type vertical-shaft pump. Power to the pumps would be provided by diesel engine through a right angle gear drive. The pumping station would have a three-bay reinforced concrete intake structure. Hydraulic design data for the pump station is given in Table 51. The estimated contract price is given in Tables 34 and 35.

The pump would begin discharging water from L-31N borrow canal when the stage rose to 5.5 feet, NGVD. Maximum pumping rate would not be initiated until the stage reached 6.0 feet, NGVD or higher. If there are downstream water supply demands, S-356 would not pump. Use of the pump station to allow vehicular access to the existing recreational area located north of the S-356 intake/discharge canals is proposed.

The final capacity of pump station S-356 would be determined in the FDM after further investigations are conducted. See Cost Estimates, Section Q.

b. S-357. Pump station S-357 would have a capacity of 533 cfs. It would pump flood waters from the residential flood protected area into the L-31N borrow canal. The pump station would be located about 1000′ west of L-31N borrow canal. A section of canal just east of S-357 would be lined with tremie concrete. When S-357 pumps, the downstream canal stages between the pump station and L-31N and in the L-31N borrow canal could rise above the canal stages west of the pump station. The impermeable canal lining east of S-357 would reduce the return seepage to about 29 cfs when pumping at capacity. The remaining 504 cfs capacity at S-357 would be for flood control. The pumping station would have three identical pumping units. The pumping bays would each contain a vertical, self-priming, axial-flow propeller or mixed-flow type pump. Power to the pumps would be provided by package-type diesel engine through a right angle gear drive. The pumping station would have a superstructure of concrete block walls and reinforced concrete columns and a three-bay reinforced concrete intake structure. Hydraulic design data for S-357 is given in Table 52. The estimated contract price is given in Tables 44 and 45. S-357 would begin pumping when interior water levels rise to 5.7 feet, NGVD, or 0.2 feet higher than the maximum non-pumping stage in L-31N. This is also the design discharge water surface elevation at the pump station. Pumping would continue until water levels fall to 4.5 feet, NGVD, at which time pumping would be discontinued.

K. HYDROLOGY AND HYDRAULICS

72. Hydrology.

a. General. The South Florida Water Management Model (SFWMM) is the primary model used in the assessment of regional water supply impacts and of hydrologic changes in the Everglades associated with each alternative plan. The model was developed by the SFWMD under contract (DACW17-81-C-0035) to the Corps of Engineers for use in the Central and Southern Florida Water Supply study; however, because of its utility, it was used in this study as well.

The SFWMM is a large scale hydrologic mathematical model capable of simulating the interaction of surface water and groundwater in south Florida. It is an analytical tool for addressing water management issues related to structural or operational changes to the C&SF project. Documentation of the model is contained in Technical Publication 84-3 "South Florida Water Management Model Documentation Report," February 1984, South Florida Water Management District. For a condensed description of the model, see Appendix B.

Most of the hydrologic analyses for the alternative water deliveries to ENP were done using the SFWMM. As described in Appendix B, the 2x2 version (two mile by two mile grid size) was used to model the entire drainage system from Lake Okeechobee southward. A more refined 1x1 version (one mile by one mile grid size) was used to model water level changes south of Tamiami Trail with major emphasis given to Northeast Shark River Slough and the developed area of Rocky Glades (East Everglades). Daily output from the 2x2 model along the Tamiami Trail supplied the boundary conditions for the 1x1 model. Appendix D, "Hydrologic Analysis of the East Everglades," describes the modeling effort using the 1x1 version. The 1x1 model incorporated numerous modifications including a new method for computing levee seepage that were not done in the 2x2 model. Likewise, the input data for aquifer depth and permeability had extensive changes in the 1x1 model that were not in the 2x2 model. As a result, the output from the 2x2 is not compatible for input to the 1x1 for high flood stages. The 1x1 model output can only be used for comparing the relative effectiveness of various structural alternatives protecting the residential and agricultural areas of Rocky Glades. It is not applicable to the rest of Dade County south of Tamiami Trail. For these impacts, the 2x2 model governs. SFWMD is making extensive modifications to both models and are also updating the input data. After recalibration, these models will be used for the FDM.

For the 1x1 model, the primary effort was the evaluation of several levee plans for mitigating increased water levels to the developed area of Rocky Glades that would occur from implementing the Rain-Driven Plan. Interior drainage and wind setup against the levees are also covered in detail. Appendix E describes the hydrologic analysis of the various alternatives using the 2x2 model. Appendix F lists the structure operations in the system for the various alternatives. The hydrology discussion which follows summarizes what is contained in Appendix D and deals primarily with flood mitigation efforts in the Rocky Glades area of the East Everglades.

b. Basin Description. The East Everglades is that area lying between the eastern Park boundary and L-31N. A one to three-mile-wide strip lying west of L-31N, as shown in the land use map Figure 2 in Appendix H, is the area adversely impacted. The area north of Richmond Drive (168th Street) has a mixture of small agricultural plots and residences and is referred to as the residential area. The area south of that is agriculture and is referred to as the agricultural area. Figure D-1 shows the three physiographic sub-areas making up the East Everglades. The northern third makes up NESRS where the water releases from the water conservation areas are to be greatly increased. This will raise water levels in the Rocky Glades area in the middle of the East Everglades. The Rocky Glades is a slightly higher outcropping of exposed limestone separating NESRS from Taylor Slough to the south. Figure D-9 gives average ground elevations in the areas of primary interest. Normal groundwater movement is to the southeast. Surface flow is toward Shark Slough and the Park. South of Richmond Drive, the flow is south to Taylor Slough. During major flooding, some spillover occurs from NESRS to Taylor Slough. There are no streams or drainage ditches. The rock is extremely porous and flooding is more the result of the water table rising above ground. The entire study area is underlain by the Biscayne Aquifer which is extremely porous limestone. The two sloughs are flooded most of the year and are largely covered with sawgrass. Trees can be found only on isolated hammocks scattered around the sloughs.

c. Historical Floods. The maximum recorded flood stage in the Rocky Glades area occurred in October 1947 following the passage of the third hurricane of the season. A stage of 9.0 ft., NGVD, was measured at L-31N and 168th Street. The area-wide average May - October rainfall of 73.54 inches has a recurrence interval of about once in 35 years. The very next year a flood stage of 8.7 feet was measured. The 1959-60 flood was another notable flood. The construction of L-29 in 1962 would have significantly reduced these stages. Since then, only the 1968-69 flood has caused widespread flooding in the area. Tropical storm "Dennis" in August 1981 caused extensive flooding and damages but it was centered more over Homestead where 19.39 inches was recorded August 16-18.

d. Assessment of Available Data.

(1) Stage and Discharge Records. There are numerous stage recording gages in the Everglades area as shown in Figure D-3. Records of flow to the Everglades National Park have been measured across the Tamiami Trail since November 1939. For the eastern Rocky Glades area, Well G-596 water levels have been recorded since July 1949. The land surface datum is 7.28 feet and the maximum observed stage was 8.30 in November 1960 before construction of L-29. Since then, the maximum was 7.95 in August 1981 but was not a result of high waters in NESRS, but rainfall centered to the south. The lowest stage observed was 0.56 feet in May 1971.

Flow records across the Tamiami Trail were examined to determine what the natural distribution of flow across Tamiami Trail was before all the structures and levees were built. The purpose of the modified water delivery project is to restore this natural distribution and volume at the appropriate time. Several correlations were attempted at relating water levels between

various gages and with discharge across the Tamiami Trail without success. It became obvious that only a computer model of the entire C&SF project that simulated structure operations and the surface water/groundwater interchange could properly evaluate the movement of water throughout the system. Seepage beneath levees was highly significant and had to be modeled accurately. The results were the development of the SFWMM.

(2) Rainfall. Rainfall records throughout south Florida were used to obtain average daily rainfall input for modeling the period 1969-82. Rainfall records at Homestead Experiment Station dating back to 1910 were used for determining rainfall frequencies in the Rocky Glades area. Annual rainfall at Homestead averages 61.13 inches and ranged from 37 inches in 1971 to 94 inches in 1947. Seventy percent of the annual rainfall occurs during the May - October rainy season. Most major flooding occurs at the height of the hurricane season in September and October. Flood levels recede very slowly and may take months to recede to non-damaging stages.

e. Stage and Discharge Frequencies. Historical stage and discharge frequencies were not relied upon for evaluating mitigation requirements because of the many man-made changes over the years affecting their magnitude. Instead, stage frequency analysis generated by the SFWMM were used.

f. Rainfall Frequency. Actual rainfall records for the period 1969-82 were used to model stage-duration data and flood frequencies for smaller flood events. Rainfall records at Homestead Experiment Station were used to develop rainfall frequencies for application in the Rocky Glades area. Table D-9 lists the hourly rainfall over a 3-day period for point rainfall on the residential and agricultural areas. The Standard Project Flood (SPF) rainfall is given in Table D-10 and was developed for a 10-square-mile area using 50 percent of the Probable Maximum Precipitation. For the 184-day rainy season, rainfall frequencies were obtained from SFWMD's Technical Publication 81-3 and adjusted to the 744 square mile area rainfall basin representing most of the Park and East Everglades area in the model (see Table D-11). The SPF in interior Florida where maximum flood stages are based on many months of rainfall has traditionally been taken to be 125 percent of the 100-year rainfall.

g. South Florida Water Management Model (SFWMM).

(1) General. A technical description of the SFWMM is thoroughly covered in Appendix B. A smaller version area wise known as the 1x1 (one mile x one mile grid) covers only the area south of Tamiami Trail and was used to model mitigation alternatives to the Rocky Glades area in finer detail than the 2x2 model was capable of. A number of modifications were made to the SFWMM 1x1 to more accurately compute levee seepage and structure operations in south Dade County. Also, more recent land elevation, aquifer depth, and permeability data were added to the input data for the Rocky Glades and NESRS areas. The 1x1 model calibration and verification are covered in Appendix D.

(2) Modeling Long-Term Impact of Water Management Plans. Fourteen years of continuous record were used to evaluate the impact of various water management plans to the residential and agricultural areas and surrounding wetlands. This period, 1969-82, included the 1969 flood having a recurrence interval of about once in 14 years and a severe drought immediately afterwards. In addition, the 25-, 100-year, and Standard Project Storm synthetic rainfall events, extending over the 6-month rainy season and using 1972 as a base year, were run on the model to predict impacts from exceptionally large floods. These impacts were measured against a base condition representing the existing conveyance system and operational policy. For the 14-year period of record, the impact of the Basic Rain-Driven Plan described in Section C, Plan Formulation, is shown in Figures D-20, 21, and 22 for the Rocky Glades area. The rise in water table levels of 0.1 to 0.3 feet under wet conditions in Figure D-20 approximates the amount of mitigation required before the plan can be implemented. The preferred Modified Rain-Driven Plan was not evaluated using the 1x1 model, but should differ very little.

h. HEC-1 Modeling of Interior Drainage. Interior drainage of the leveed areas of Rocky Glades were evaluated to make certain levees would not worsen flooding. The 2- and 10-year discharges were used as input to sizing seepage collection channels. An average wet season stage was determined prior to the onset of 3-day rainfall. Storm loss rate was computed using Holtan's equation and a soil porosity of 19 percent and constant percolation rate of .01 in./hr. Most of the percolation is groundwater flow to L-31N. Base flow along one side of the canal was computed using a groundwater seepage equation derived in C&SF GDM, Part V, Supplement 52. Rainfall excess was routed overland using the kinematic wave equation. The resulting 10-year, 24-hour discharge was around 55.9 cfs/sq.mi., or 2.08 inches/day which compares favorably with other studies in south Florida. Flood routings through storage behind the levees showed no worsening of flooding with the levees in place. Peak discharge frequencies are given in Table D-16.

i. Hydrologic Design.

(1) Level of Protection and Sizing of Pumps. During preliminary investigations, several levee plans were investigated, some of which included detention areas. These plans evolved into the seven alternatives investigated in the GDM. One of the initial conditions established for sizing the interior drainage was that it either handle the average annual peak daily discharge in conjunction with the levee seepage rate for mitigation or handle the 10-year runoff with no levee seepage, whichever was greater. This latter requirement was chosen because most of the C&SF drainage projects for agricultural lands in south Florida are for 10-year protection. This latter requirement only governed in a couple of instances at the remote end of the seepage collection channel.

Initial pump sizes were approximated by assuming 0.2 feet of mitigation or head loss across the levees. Plans A and B described on page 35 were the outcome. Discharging over the levee into NESRS aggravated seepage and full mitigation was not achieved in the residential for the larger flood events. Plan C, designed to give complete protection from the 1969 flood to

the residential area, more than met mitigation requirements for the extreme flood events in the residential and agricultural areas. Plan D attempted to reduce seepage losses to the East Coast along L-31N by pumping it to a 1340 cfs pump as in Plan C and then into NESRS. This plan failed to mitigate flooding in the residential area for the larger flood events. Plan E resolved environmental objections by discharging levee seepage in the residential area into L-31N using a much smaller pump and then pumping that amount plus an additional 500 cfs seepage along L-31N into the L-29 borrow canal at the top of NESRS. A 300 cfs and a 400 cfs pump were modeled for the residential area. The 400 cfs pump best mitigated increased flooding at all nodes behind the levee and south of 168th Street in the agricultural area. An additional 70 cfs was added to the 400 cfs to take care of return seepage around pump station S-357. A 240-foot reach of the canal just east of S-357 requires concrete lining so return seepage is not double this figure. Plan F is identical to Plan E except the need for protection from hurricane wind setup was dropped eliminating the need for the south levee and lowering levee heights by 6 to 8 feet. Plan G, the recommended plan, is the same as Plan F except that pump station S-357 is moved 2 miles north to reduce land costs. This increases pump size to 533 cfs and 950 cfs at S-357 and S-356, respectively. Table D-20 summarizes the major features of the seven plans.

(2) Levee Design Grade. Plans F and G levee grades were set at 1.0 foot above the SPF stages bordering NESRS. Table D-22 specifies the elevation and location of levee grades for Plans F and G. Table D-22 gives the levee grade for Plans F and G.

j. Modeling Results. Table D-23 compares the stage-duration-frequency data for the various alternatives against Base Condition for the residential area at Well G-596. Table D-24 does the same for a representative node in the agricultural area.

Figure D-20 compares the increase and decrease in percent of time flooded for the Rocky Glades area for the Basic Rain-Driven Plans E, F, and G. It shows a reduced percentage time of flooding in the residential and agricultural areas as expected. Not evident are the benefits derived during droughts. Figure D-22 gives some indication of increased water table levels during dry conditions.

73. Hydraulic Design.

a. Hydraulic Design Criteria.

(1) General. Hydraulic design criteria and procedures used herein are in accordance with standard engineering practice and applicable provisions of the Corps' Engineering Manuals and the Waterway Experiment Station's "Hydraulic Design Criteria", relative to the design and construction of Civil Works Projects.

(2) Water-Surface Elevations. Water surface elevations in the area are discussed in detail in the hydrology section and plan formulation section.

(3) Canal Characteristics.

(a) Maximum Permissible Velocities. Studies of canals excavated in the area located in similar material indicate that average velocities up to 2.5 feet per second would not cause serious scouring in the proposed canals excavated in the earth sections. An average velocity of 3.5 feet per second would not cause scouring in the residential area canals excavated in soft rock. This is in accordance to EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", page 36. Velocity limitations were not exceeded due to the limited hydraulic head differentials available.

(b) Side Slopes. Canal side slopes were based on the most economical and stable slopes for the types of materials found in the area. The side slopes satisfying these criteria vary from one vertical on one horizontal (1V:1H) for areas with rock to 1V:3H for areas without rock.

(c) Transitions. Gradual transitions are proposed wherever cross-sectional dimensions of the canals are changed.

(d) Water Surface Profiles and Canal Sections. Canal sections were determined by application of Manning's formula. Conveyance was determined from the available differential water surface and Manning's "n". Water surface profiles were determined and checked by using the HEC-2 Computer Program, "Water Surface Profiles", developed by the Hydrologic Engineering Center in Davis, California. A Manning's "n" value of 0.035 was used for areas with rock and 0.030 for areas without rock. This is consistent with criteria used for other project areas in Florida.

(4) Water Control Structures.

(a) Culverts. The corrugated-metal-pipe culverts with stoplog risers or vertical lift gates were designed in accordance with criteria and procedures developed for the Central and Southern Florida Project. These criteria are partially presented in Part VI, Section 13, DDM, "Hydraulic Design of Inlet Structures". The remaining criteria are site specific and are listed in the data tables for the culverts.

(b) Spillways and Weirs. Hydraulic design of control structures conform with standard design criteria and procedures established in EM 1110-2-1603, "Hydraulic Design of Spillways", and EM 1110-2-1602, "Hydraulic Design of Reservoir Outlet Structures".

b. Structural Water Control Features.

(1) Gated Culvert Structures S-345A, B, and C. The S-345 structures consist of three sets of three 72-inch diameter gated culverts. Each set is located 6,000 feet apart with a capacity of 500 cfs for each set. Their purpose is to discharge water from L-67A borrow canal into WCA No. 3B through Levee 67A. The culverts are connected to canals along L-67C and would extend

1,000 feet into WCA No. 3B. The canals would have levees on both sides between L-67A and L-67C. Table 47 presents a summary of hydraulic design data for the culverts and canals. A plan view of the culverts and canals is shown on Plate 22. Plate 18 shows a section view of S-345A.

(2) Gated Water Control Structures S-349A, B, and C. These structures would consist of sheetpile walls with four gates mounted on the face of each wall. The structures are located in levee 67A borrow canal. The layout of these structures in relation to the S-345 structures is shown on Plate 25. A summary of hydraulic design data is given on Table 48. The structures are similar to those discussed in Part I, Supplement 53, DDM, "Structures 339 and 340". The S-349 structures are designed to pass 1,250 cfs to S-333 with 0.2-feet of head loss. The top of the structure would be elevation 12.0 feet, NGVD, which exceeds the highest historic stage.

(3) Spillway Structures 355A and B. S-355A and B are gated spillway structures located 12,400 feet apart in L-29. The structures' purpose are to provide discharge capacity out of WCA No. 3B into Levee 29 borrow canal. A 1,000-foot collector canal would be located in WCA No. 3B adjacent to L-29 to supply water to the structures. The structures would discharge into the L-29 borrow canal. A summary of hydraulic design data is given in Table 49. A plan view of the structures is shown on Plate 23. Plate 20 shows a section view of S-355A and B.

(4) Replacement of Spillway S-334. S-334 is an existing concrete single bay gated spillway located in L-29 borrow canal 1,500 feet west of L-30 borrow canal. See Plate 17 for the location. The existing spillway is not structurally stable for the proposed operating water surface elevations. Replacement of S-334 would provide protection for areas east of S-334 from SPF stages on L-29. Replacement of S-334 includes: constructing a new spillway west of the existing spillway in L-29 borrow canal, providing tie-back levees to Levee 31 North, and raising U.S. 41. The levee, U.S. 41 and S-334, would be constructed to elevation 17.4 feet, NGVD, to provide SPF plus wind and wave setup. No discharge will be made from S-334 during an SPF event. See Table 50 for hydraulic design data for S-334.

(5) Pumping Station S-356. The proposed pumping station is located in Levee 29 borrow canal adjacent to S-334 and would pump excess water from Levee 31N borrow canal into the Levee 29 borrow canal. The pumping station would have three pumping bays giving the pumping station a total discharge capacity of 950 cfs. Hydraulic design data for the pump station is given in Table 51. See Plates 17 and 24 for plan views.

(6) Small Boat Bypass Channel. This feature would consist of adding small boat bypass channels around the levee at each of the S-349 structures. Low speed navigation of the channels would be available in all but the most extreme drought conditions. Each bypass channel would have a bottom width of 24 feet and a bottom elevation set at elevation +4.0 feet, NGVD. Entry points to each channel would be at 300 feet upstream and 200 feet downstream of each proposed S-349 structure. The radius of the turn around the end of each levee would be set at 86 feet. This would produce long sight lines to allow ample time for maneuvering to avoid oncoming vessels. Boaters would

be required to traverse the channels at idle speeds for safety reasons. Figure 21 shows a typical plan and cross section view of a channel. Flow in the channel would occur when head differences are established across S-349A, B, and C. The following table shows velocity verses discharge and corresponding head loss at S-349A.

Bypass Channel Flow Conditions

Head loss at S-349C feet	Discharge cfs	Water Depth feet	Flow Velocity fps	mph
0.1	45	3.1	0.44	0.30
0.2	65	3.2	0.61	0.42
0.3	85	3.3	0.76	0.52
0.4	100	3.4	0.85	0.58
0.5	115	3.5	0.95	0.68

c. Residential Area Water Control Alternatives.

(1) Recommended Plan G. Plan G would provide flood control for the residential area located on the west bank of L-31N between S-331 and S-24A. Plate 15 shows the basic layout and features of Plan G. This plan consists of providing two parallel levees and a canal along the north and west boundaries of the residential area. The levees would provide protection against high stages in ENP and reduce seepage to the residential area. The canal would collect waters expected to seep under the levees and convey those waters to a new pump station designated S-357. Collected seepage would then be pumped into L-31N borrow canal. S-357 would have a capacity of 533 cfs and would be located about 0.2 mile west of L-31N, and about 0.5 miles north of Canal 1. Plate 27 shows an enlarged plan view of the alignment and features of the levee, seepage canal and pump station S-357. Plates 28 through 32 show cross section profiles of typical sections across selected reaches of the seepage levee and canal alignment. About two hundred and forty feet of the canal from S-357 to L-31N would be concrete lined to reduce back seepage. The remainder of the canal would be unlined. Hydraulic design data for S-357 are shown in Table 52. Hydraulic design data for the levees and seepage canal are shown in Table 53.

Plan G also includes an additional pumping station, designated S-356. This station would be located in the L-29 borrow canal. S-356 would have a capacity of 950 cfs and would pump water from the L-31N borrow canal to the L-29 borrow canal. Hydraulic design criteria for S-356 are shown in Table 51. Plate 23 shows the plan view of S-356 with upstream and downstream approach channels to L-29 Borrow Canal.

(2) Other Plans Considered.

(a) Plan A. Plan A would also provide flood protection for the residential area. The levee alignment and pump station features are shown on Plate 9. Two parallel levees would protect against high stages in ENP and reduce seepage. A canal would collect seepage and convey water to a new pump

station, designated S-357. S-357 would have a capacity of 841 cfs and would pump directly to NESRS. Canal stages would be maintained near ground level by weirs placed in the canals. The high water levels would further reduce seepage. Plate 9 shows a plan view of the levee alignment and features of Plan A. Hydraulic design data for the levees and seepage canal are shown in Table 54. Hydraulic design data for the weirs are shown in Table 59.

(b) Plan B. Plan B would provide flood protection for the residential area in Plan A plus the agricultural area to the south. The levee would be continued south to provide flood protection to almost double the area provided by Plan A. A plan view of Plan B is shown on Plate 10. In addition to S-357, a 404 cfs pump station would be located in the southwestern corner of the project area. Runoff from the agricultural area would be pumped directly into NESRS. Canal design data for the agricultural area is listed on Table 55. The canal reach locations are shown on Plate 10. Table 59 lists data for the weirs in the residential area and Table 60 lists data for the weir in the agricultural area.

(c) Plan C. Plan C would provide water control for the urban area in Plan A plus the agricultural area south. A plan view of Plan C is shown on Plate 11. A 1,332 cfs pump station would remove seepage from the agricultural area by pumping directly into NESRS. Canal design data for the agricultural area is listed on Table 56. The canal reach locations are shown on Plate 11. Table 61 lists data for the weirs in the plan.

(d) Plan D. Plan D would provide flood control for a residential area located on the west bank of L-31N between S-331 and S-24A. Plate 12 shows the basic layout and features of Plan B. This plan consists of providing two parallel levees and a canal along the north and west boundaries of the residential area. Closure with L-31N would be provided by a levee parallel to Richmond Drive. The levees would provide protection against high stages in ENP and reduce seepage to the residential area. The canal would collect waters expected to seep under the levees and convey those waters to pump station S-357. Collected seepage would then be pumped into L-31N borrow canal by S-357. S-357 would have a capacity of 500 cfs. One additional pump designated S-356 with a capacity of 1,340 cfs would be provided. That pump would discharge directly into NESRS. Canal design data for the agricultural area is listed on Table 57. The canal reach locations are shown on Plate 12.

(e) Plan E. Plan E would be identical to Plan D with the exception that pump station S-356 would have a capacity of 900 cfs and would be located adjacent to S-334 in L-29. The residential area interior drainage canals would provide conveyance to S-357. S-357 would have a capacity of 470 cfs and would pump directly into L-31N borrow canal. Plate 13 shows a plan view of the alignment and features of Plan E.

(f) Plan F. Plan F would have had the same alignment and features as Plan E, except that the southerly reach of levee which would have formed closure with L-31N, would be eliminated. A plan view of Plan F is found on Plate 14. Canal design data for the interior drainage canal system is shown on Table 58.

d. L-67A Borrow Canal Boating Access.

(1) Problem Description. The entire 25.9 mile length of the L-67A borrow canal from its southern end at Tamiami Trail to the Everglades Holiday Park and S-9 at its northern end is utilized by recreational boating interests. The canal is a very important recreational resource for Broward and Dade Counties. Boaters launch their craft at both ends of the canal and currently have unrestricted access to the entire length of canal. Boat ramps are located at Tamiami Trail and at Everglades Holiday Park . The recommended plan contained in the draft GDM included the addition of three structures in the L-67A borrow canal. A low levee would be constructed from each structure perpendicular to the canal for about 1,000 feet into the marsh. These structures would eliminate boating access to the middle portions of the canal. This issue was raised during the public review/comment period for the draft GDM and EIS.

(2) Alternatives Considered. A number of potential alternatives were evaluated to maintain boating access. Although several alternatives were eliminated because they were not practical or were too expensive, eight alternatives (including the plan proposed in the draft GDM) were evaluated in more detail. These alternatives are described below:

(a) Plan 1 - S-349A, B, and C Without Boating Access. This plan consists of the features recommended in the draft GDM. Boating access would be maintained in the 6.4 mile section of the canal immediately north of Tamiami Trail and the 10 mile section of canal south of the Everglades Holiday Park (S-9). However, the middle 9.5 mile section of canal would not be accessible to boats. Figure 16 shows a plan view of the structure layout.

(b) Plan 2 - Boat Notch Option. This alternative consists of all the features of Plan 1 described above, with the addition of a notch in the sheet pile wall adjacent to each structure. The notches would be as small as possible to provide for navigation under most conditions and to minimize the flow of water. Each notch would be 20-feet-wide and 3-feet-deep under low water conditions. Boaters would be required to traverse the notches at idle speeds for safety. Figure 17 shows configuration and relative location of the notch.

(c) Plan 3 - Boat Lock Option. This option would include the addition of boat locks adjacent to each structure. Lock operators would be required for operation at each structure. This alternative would require that power be provided at each structure. Figure 18 shows a plan views of a typical boat lock.

(d) Plan 4 - Boat Lift Option. This option would include the addition of a boat lift at each structure. The boat lift would allow individual boat operators to manually hoist the boats across the structures.

(e) Plan 5 - Partial Plug Option. This alternative would call for replacing the structures with plugs. The plugs would be constructed by backfilling sections of the canal to the maximum elevation that would allow navigation over the plug. About 3-feet of water depth would be provided at

each plug during low water conditions. Boaters would be required to traverse the plugs at idle speeds. Figure 19 shows a profile view of the configuration of typical plug.

(f) Plan 6 - Six Spur Dike Option. This alternative would consist of constructing six spur dikes in the canal. Each spur dike would be constructed by filling the canal to a shallower bottom elevation and a narrower width. The construction of six spur dikes (vs. 3 structures) would necessitate smaller head losses at each structure to accomplish the same hydrologic objective. Figure 20 shows plan and profile views of the features of this option.

(g) Plan 7 - Bypass Channel Option. This option would consist of modifying Plan 1 by adding small boat bypass channels around each of the levees at the structures. The bypass channels would be constructed to the minimum cross section required to allow navigation under most conditions. Boaters would traverse the channels at idle speeds for safety reasons. Figure 21 shows a plan view of the features of this option.

(h) Plan 8 - No Structures Plan. This plan would completely eliminate S-349A, S-349B, and S-349C. Boat access would remain the same as under existing conditions.

(3) Evaluation of Alternatives. Seven criteria were utilized in the evaluation of alternatives: maintenance of fishing access; ability to obtain the project's hydrologic objectives; impacts on water management; navigation safety; environmental impacts of constructing the boating access features; and, impacts on project costs. All boating access alternatives were evaluated relative to Plan 1 (the recommended plan in the draft GDM). Figure 22 summarizes the evaluation of the alternative plans. A description the evaluation criteria follows:

(a) Fishing Access. The goal of this evaluation was to identify a plan that would maintain boating access in the L-67A borrow canal to the extent possible without unacceptable deterioration in the project's hydrologic objectives. Each of the alternatives (except Plan 1) would maintain boating access under all or most conditions. The boat notch, plug, spur dike, and bypass channel options would require that boaters slow to no wake speeds. Under extreme drought conditions, these options may not maintain navigation.

(b) Impacts on Hydrologic Objectives. S-349A, B, and C would provide two important hydrologic functions: 1) the structures would produce a more natural water distribution in WCA No. 3A by block flow in L-67A borrow canal; and, 2) the structures would raise water levels upstream of S-345A, B, and C thereby increasing the ability to discharge water from WCA No. 3A to WCA No. 3B. Alternative means of providing boating access were developed with the goal of minimizing or avoiding any significant impact on the overall project objectives. The no boat access boat lock and boat lift options would all fully maintain the hydrologic objectives. The bypass channel option would result in slight increases in flow. However, the minimal size of the channel and the 2,800 channel length would be hydraulically inefficient enough to produce only negligible flows. The boat notch, plug, and spur dike options

would significantly reduce the overall hydrologic objectives. These options would result in increased hydraulic efficiencies that would cause large increases in flows past the structures. Consequently, these options were found unacceptable.

(c) Impacts on Water Management. During drought periods, the L-67A borrow canal conveys water through WCA No. 3A for delivery via S-333 and S-334 to the ENP - South Dade Conveyance System. Additionally, as a part of the Modified Rain-Driven Delivery Plan, the canal conveys water required to maintain an adequate pool in southern WCA No. 3A to provide snail kite habitat. S-349A, B, and C were designed to pass the bank full capacity of the canal with a minimum of head loss in order to preserve the water supply conveyance capacity. The no boat access, boat notch, lock, lift, and bypass channel options all preserve the water management capacity. The plug option essentially would eliminate any canal conveyance capacity under drought conditions and, as a result, was found to be unacceptable. The spur dike option would reduce the canal cross section at six locations and would reduce the canal's conveyance capacity.

(d) Navigation Safety. Any option selected must provide a safe means of navigation under the full range of potential conditions, from extreme high water conditions to extreme low water conditions. In order to meet the hydrologic objectives of the project, S-349A, B, and C were designed to maintain a head under high water conditions. With the boat notch option, the head across the structure under high water conditions would result in high water velocities through the notch. This would be dangerous to navigate and, therefore, the notch alternative would be unacceptable. Under low water conditions, the plug option would present a hazard to navigation. The plug would be constructed so that three feet of depth would exist under all but extreme drought conditions. When water levels were extremely low, the plug would be submerged and would not be visible. Although warning signs would be required, boaters that did not see the signs or heed the warnings could incur damage or injury if they attempted to cross the plugs, especially at a high rate of speed. The boat lift, boat lock, and spur dike options would provide safe navigation. However, the boat lift option could be hazardous because it would require boaters to operate the lift themselves. The boat bypass channel option would require boaters to travel at idle speeds through the bypass channels. The structures would be clearly visible to boaters traveling down L-67A borrow canal and they would be forced to slow down before entering the bypass channels.

(e) Environmental Impacts. The goal of this project is to restore natural hydrologic conditions in the Everglades for the benefit of the native fish and wildlife species. Therefore, the environmental impacts of constructing the boating access alternatives was an important criteria in the evaluation. The boat notch, boat lift, partial plug, and spur dike options would result in little or no additional environmental impacts. The boat lock would cause the loss of approximately 9.0 acres of wetlands associated with construction of the channels. The boat bypass channels would cause the loss of approximately 8.7 acres of wetlands associated with construction of the channels.

(4) Recommended Plan.

(a) Description. Plan 7 is the recommended plan. This plan calls for adding small boat bypass channels around each of the levees at the S-349 structures. Low speed navigation of the channels would be available in all but the most extreme drought conditions. The canal depth would be about three feet during low water conditions. The bottom width of the channels was set to allow single boat slow speed passage around the structure. Entry points to each channel would be at 300 feet upstream and 200 feet downstream of each proposed S-349 structure. The radius of the turn around the end of each levee was designed to produce long sight lines which would allow ample time for maneuvering to avoid oncoming vessels. Boaters would be required to traverse the channels at idle speeds for safety reasons. Figure 21 shows a plan view of a typical channel.

(b) Cost Comparison. Cost for boat locks, boat lifts and the boat bypass channel were made for comparison. Three locks, one at each S-349 structure, would cost about $9,300,000. Boat lifts at each structure would cost about $297,000. These two extremes would require operation of mechanical equipment. The lock would require a full time operator and electrical power. The boat lift could be operated by individual boat owners but is considered dangerous for inexperienced operators. Operation and maintenance cost of these alternatives is expected to be high. Mechanical failure and vandalism could create very hazardous and inconvenient conditions. In addition, both of the above plans would cause time delays for the users. The boat bypass channel would cost about $407,000 for the three channel required. This cost compares favorably with the smaller cost of the lift mechanism. Operation and maintenance costs would involve control of aquatic weeds. Cost due to sedimentation are expected to be minimal due to the low velocities and the fact that the channel would be constructed in rock.

L. TOPOGRAPHIC INVESTIGATIONS

74. General. Accurate topographic data were critical to hydrologic modeling and the assessment of impacts in this study. Therefore, a great deal of effort was expended in the compilation of the best possible data. Four main sources of data were utilized: existing Corps and SFWMD survey results for levees and canals; USGS quadrangle maps primarily in the urban and agricultural areas of south Florida east of L-31N; recent ENP survey results in NESRS and ENP; and, a contract to obtain detailed topographic data within the developed East Everglades area.

75. Developed East Everglades Topography. In order to fully assess potential impacts of the proposed plan in the developed portion of the East Everglades, accurate topographic data were necessary. Although some data had previously been collected by other agencies, it was not of satisfactory detail or tolerance. Therefore, detailed topographic data were obtained under contract (DACW17-86-C-0016). The data includes spot elevations at 300-foot intervals taken to + 0.2 foot accuracy. Based on these data, half-foot contour lines were established. The area surveyed included all residential and agricultural

lands in the East Everglades, as well as a strip of transitional area along the western edge. The survey also included a profile and cross section of Grossman's ridge from Grossman's Hammock to the ridge's western tip near L-67 Ext. Data obtained in this survey were used in the hydrologic modeling and assessment of potential impacts.

76. Northeast Shark River Slough Topography. ENP obtained topographic data for all of Shark River Slough and NESRS. Although all of these data were not available for this study, data were obtained for the full width of Shark River Slough and NESRS from Tamiami Trail southward to about the tip of L-67 Extension and for the remaining portion of NESRS southward to L-31W. The data consisted of east-west cross sections taken at one kilometer intervals with spot elevations approximately every 400 feet along each section. A more detailed survey was obtained by ENP for the NESRS area at the end of 1988. The same topographic data were available for use to the Corps in 1989, and were utilized for assessment of potential impact in the area.

M. GEOTECHNICAL AND MATERIALS

77. General. Subsurface and material information in the proposed construction areas is available from previous canal, levee, and structure investigations. Additional investigations will be performed and included in subsequent Design Memoranda. Geotechnical analysis for this report is included in Appendix G (Geotechnical Investigations).

N. REAL ESTATE INVESTIGATIONS

78. General. The lands, easements, rights-of-way needed to implement the modified water deliveries element of the project north of Tamiami Trail are currently owned by the South Florida Water Management District and have been previously provided to the United States as part of the Central and South Florida Flood Control Project. The lands, easements, rights-of-way south of Tamiami Trail needed to implement the modified water deliveries element will be purchased in fee by the Department of Interior under Section 102 of the Everglades National Park Protection and Expansion Act of 1989 (P.L. 101-229) except for 10 acres immediately south of Tamiami Trail which was excepted from the Act. A perpetual easement will be acquired over this 10 acres.

The lands, easements, rights-of-way and relocations needed to implement the residential protection features of the project will be acquired and performed by the United States. These lands for the levees, canals, and pump station will be acquired in fee. The total estimated cost for implementing the real estate project features in the residential area is approximately $6,913,413 as shown below:

Estimate of Cost (Date of Value March 1990)

a.	Lands and Damages	
	Land (acres fee 650.8) (300 owners)	$2,548,000
	Improvements (located on flowage easement)	$ 53,000
	Flowage Easement 10 Ac (1 owner)	$ 117,000
	Minerals	$ None Known
	Severance	$ 16,000
	Total Land and Damages	$2,734,000
b.	Acquisition - Administration cost *	
	Federal	$2,687,400
	Non-Federal	$ -0-
c.	Public Law 91-646	$ 109,330
	Relocations	$ -0-
	Subtotal	$5,530,730
d.	Contingencies 25%	$1,382,683
e.	Total Estimated Real Estate Cost	$6,913,413

Acquisition of the entire developed area in the East Everglades area was considered an alternative to flood mitigation. Estimated cost to implement this alternative ranges from approximately $43,352,000 to $78,213,00. Therefore, flood mitigation was selected as the preferred alternative. Specific details of real estate aspects of this project, including a draft Local Cooperation Agreement and Indian Issue Paper, are addressed in the Real Estate Design Memorandum No. 1 dated March 1991, on file in the Jacksonville District Office.

O. ENVIRONMENTAL INVESTIGATIONS

79. General. The Everglades ecosystem was at one time a vast freshwater wetland. Prior to the authorization of the C&SF Project, a great deal of construction had been done specifically for the purpose of draining the Everglades. The first works began in 1881 when canals were constructed to lower water levels in the Kissimmee River Basin. By 1927, six major canals had been constructed in the Everglades Drainage District. These canals were intended to drain water from Lake Okeechobee and the Everglades to tidewater for the purpose of making Everglades muckland available for agricultural production. Everglades National Park, at the southern end of the original Everglades, was authorized in 1934 and established in 1947 due to its natural and scenic values contained within. Today, the Everglades supports a variety of land uses, ranging from intensively managed agricultural areas in the north, to water conservation areas in the middle regions.

Man's continued development of the Everglades and surrounding areas has interrupted the natural flow regime. Prior to development, water would overflow the southern end of Lake Okeechobee during wet years. Water flowed southward in a thin sheet to Florida Bay and eastward to tidewater through transverse glades in the coastal ridge. Presently, water is routed through a series of man-made canals and stored in Lake Okeechobee and the water conservation areas for delivery to ENP and for other uses such as water supply in south Dade County.

80. Issues. Water is crucial to the Everglades ecosystem and has a direct effect on the plants and animals of the wetlands. Inundation patterns, along with other factors, determine the distribution and composition of the vegetation communities within the ecosystem. The hydrologic regime also influences chemical composition, nutrients and water quality within the ecosystem.

81. Impact of Hydrologic Changes. Distribution of water deliveries since the early 1960's affected wading bird populations in two ways. First, concentration of water flows into the northern portion of ENP resulted in longer hydroperiods and incomplete dry season drawdowns. Often, food was not available or sufficient to support wading birds nesting attempts. Second, the already reduced foraging area available to wading birds was sharply diminished by eliminating flow to northeast Shark River Slough. This probably resulted in substantial decline in aquatic productivity and loss of dry season feeding habitat. The freshwater fish community has also been effected by the changed water conditions in the Everglades. Fish population densities are highest in

marshes with seasonally fluctuating water depths and extended hydroperiods. In marshes with short hydroperiods (less than 11 months) fish populations decline. The continued reduction in hydroperiod in the Everglades since the 1960's has contributed to the decline of the fish population.

82. Expected Project Benefits. The recommended structural modifications to the C&SF project are expected to benefit the ENP ecosystem in general. Those modifications would allow greater flexibility for water deliveries than the more rigid schedule specified in PL 91-282. It would effectively control dry-down and permit correlation of early summer and maximum surface water levels. The seasonal hydroperiods and increased areas of flooding resulting from implementation of the project, especially in marshes peripheral to the central Shark River Slough and east of the existing ENP boundary, are expected to improve overall feeding conditions for wading birds.

The increased hydroperiods of the peripheral marshes, especially in the northeast Shark River Slough area, would preserve and increase fish populations and make them available to predators. The fluctuating water conditions in the Shark River Slough basin and the residual pools in the slough would serve as refuge and source of fish to recolonize additional flooded areas in the wet season. Overall, the Everglades ecosystem would benefit from the recommended plan. For further details, see the Environmental Impact Statement and other documentation.

P. ECONOMIC ANALYSIS

83. General. The benefits from a water resource project are the value of increases to the output of the nation and the cost savings in maintaining a given level of output. The economic analysis of alternative water delivery plans focused on expected flood damages to the residential and agricultural areas associated with the basic rain-driven alternative in combination with various mitigation plans. Without mitigation, the basic rain-driven plan would result in an increase in expected flood damages. For each plan which included mitigation, expected flood damages would be less than damages expected without a project. Those plans would fully mitigate for the potential increase in flood damages and, in addition, would provide incidental flood damage reduction benefits. Selection of the recommended plan was based on factors other than cost and economic benefits. Environmental issues were coordinated with other Federal agencies and weighed heavily in selection of the recommended plan.

Q. COST ESTIMATES

84. General. The Recommended Plan presented herein is shown on Plate 17. This plan would consist of constructing three culvert structures, three gated concrete headwall water control structures, three spillways, two pumping stations, raising U.S. 41 and L-29 recreation area, degrading L-67 Extension, and flood mitigation for the residential area and a Miccosukee Indian Camp. The total estimated cost of the Recommended Plan is $81,330,000, at February

1991 price levels. This estimate is the "base line" estimate, and does not account for future price escalation. A full funded cost estimate reflecting anticipated price escalation was developed to identify projected construction costs. This estimate is based on standardized future escalation factors from the Office of Management and Budget. The full funded cost estimate is shown on Table 17. A summary of Federal and non-Federal costs including operations and maintenance, repair, replacement, and rehabilitation costs is presented in Table 17A. The base line cost estimates for the Recommended Plan is found on Table 18. Cost estimates for individual features of the Recommended Plan are found in Tables 19 through 45.

85. Contingencies. Contingencies used for cost estimates were either 20% or 25% of the cost of each individual line item. The following criteria were taken into consideration when determining the amount of contingencies to use:

a. Level of Design. Design effort involved sizing primary feature dimensions (spillway bay openings, channel widths, etc.) based on hydrologic requirements and using comparable structures constructed on previous projects.

b. Availability and Accuracy of Subsurface Information. The Geotechnical design was based on available pump test data and existing borings in the vicinity of the project. There are existing core borings near the project area which are representative of the existing foundation conditions. No borings were drilled at the actual project site. However, during the FDM design stage, more core borings and pump tests will be done to better define the subsurface conditions and allow a more detailed analysis and design.

(1) Pump Station Cost Contingencies. Pump station S-356 was designed to convey residential area flood waters plus groundwater seepage into L-31N borrow canal caused by increased water levels in NESRS and the resulting additional seepage. Transmissivity of the pervious limestone aquifer, measured by pump tests, is well documented and was used to design the capacity of S-356. However, during large storm events, which this project is designed to mitigate for, measured transmissivities with water stages standing above ground level are not available and were computed theoretically. A critical element for computing canal seepage during extreme events is the presence of an impermeable organic peat layer covering the limestone aquifer. During feature design, a geotechnical investigation will determine the extent of this impermeable layer. The pump station capacity recommended in the GDM is based on estimates of seepage assuming a partial covering of organic material which reduces the transmissivity. This estimate is consistent with field operating observations of pumping at S-331. The contingency amount is based on the complete absence of the impermeable layer and the resultant requirements to limit seepage into the canal and increase the capacity of S-356. If necessary, additional seepage control measures could include canal improvements to L-31N to flatten and raise the water surface; canal improvements to L-29 to reduce the water stages near Tamiami Trail; a double levee along L-31N; and additional pump capacity for S-356.

c. Method Used for Estimating Quantities. Construction quantities for levees and canals were determined by applying an average design cross-section

and an average ground elevation over a measured length. In general, the ground elevations varied less than one foot.

d. Method Used for Developing Costs. Historical data was used to determine unit prices and lump sum costs when it was available for similar projects. When historical data was not available, unit prices were developed using standard estimating procedures.

R. OPERATIONS AND MAINTENANCE

86. Project Regulation. Upon completion and after meeting all requirements set forth in PL 101-229, the project would be operated in agreement with the criteria established in this report and in accordance with a Preliminary Water Control Plan contained in the Water Conservation Areas (WCA's), ENP, and ENP-South Dade Conveyance Canals Water Control Manual. The Water Control Manual will be prepared according to guidance prescribed in the Engineer Regulation for Water Control Management and the Engineer Technical Letter for Preparation of Water Control Manuals. The WCA's, ENP, and ENP-South Dade Conveyance Canals Water Control Plan will be prepared after approval of this report. The complete Water Control Manual, incorporating interim and ultimate regulations for ENP water supply, will be prepared at a later date. In accordance with PL 101-229, a periodic evaluation of the operating criteria would be conducted after the project is fully implemented. Thorough analysis and testing studies will be made as necessary to establish an optimum water control plan within prevailing constraints. Any future changes in the operating criteria of the project will be fully coordinated with the sponsor and appropriate local, State, private interests, and other Federal agencies. In addition, the proposed project features would be maintained, repair, replaced, and rehabilitated in accordance with an Operations and Maintenance Manual prepared for the project.

87. Operations and Maintenance (O&M). Operations and maintenance, repair, replacement and rehabilitation (OMRR&R) of all proposed structure modifications of the C&SF project, including the pumping stations and levee and canal system, would be 25 percent non-Federal and 75 percent Federal as outlined in paragraph 3 of this report and according with the Local Cooperation Agreement. Operations would be performed in accordance with instructions prepared and incorporated in the "Operations and Maintenance Manual for the Central and Southern Florida Project". The contractor would be responsible for maintenance during construction. The Corps will retain O&M responsibility for all structures, and for interim O&M of the pumping stations and levee and canal system until final transfer to the sponsor. Table 46 shows a summary of estimated O&M costs.

S. DESIGN AND CONSTRUCTION SCHEDULE

88. General. Following approval of this report, three feature design memoranda would be prepared for the recommended plan. It is anticipated that a construction start would be schedule for Fiscal Year 1993.

89. Construction Time. An estimated construction time of five years would be required for completion of the project. Figures 12 and 13 show the construction schedule. There will be three construction activities that depend upon the availability of lands to be acquired by DOI; construction of a tieback levee at Tamiami Trail and L-31N, completion of the levee/canal system for flood mitigation in the East Everglades residential area, and removal of L-67 Extension. The lands required for construction of the tieback levee at Tamiami Trail have already been acquired by DOI. When the levee/canal system is constructed, access beyond the levee will be provided at two road crossings. This will maintain access to remaining parcels in the acquisition area. Access beyond the levee will closed only when the parcels that are accessed by these roads have been acquired. Currently, closure of the road crossings is scheduled to be performed as a part of the final contract. However, this work can be rescheduled for an earlier contract if DOI acquisition allows it. Although L-67 Extension is within the existing ENP boundary, degrading the levee will allow more flow through the East Everglades area to be acquired by DOI. Consequently, this levee cannot be degraded until all affected lands have been acquired and construction of the flood mitigation system and pump stations S-356 and S-357 have been completed. This is the last order of work. All of these activities have been coordinated with DOI and land acquisition is proceeding accordingly.

90. Phased Construction. Phased construction would generally call for constructing a portion of a project and then, over period of time, evaluating whether the remaining project features would be required to achieve the desired benefits. This strategy would offer the advantage of identifying unnecessary project features and would allow an opportunity to correct design deficiencies for the remaining project features. However, advantageous use of phased construction would require the project to be composed of two or more separable features that could be constructed individually to accomplish at least a portion of the project purposes. The proposed project does not have any separable features. Therefore, this report recommends the project be implemented as a whole rather than through phased construction.

The Modified Water Deliveries to ENP Project could be divided into two features: 1) the flood mitigation works and degrading L-67 Extension, and, 2) the structural modifications required to restore flows through WCA No. 3B. Phased construction would require that the flood mitigation works and degrading of L-67 Ext. be accomplished first. The first phase of the project would address hydrologic changes south of Tamiami Trail, while the second phase would address hydrologic changes north of the highway. Implementation of this project through phased construction would not be advantageous because the separable project features could not be implemented individually to achieve a portion of the project benefits. The first phase would not allow restoration of historic flows across the full width of Shark River Slough.

Structure 333 would be the only means of discharging water across the ten-mile flow-way of NESRS. Under wet conditions, the S-12 discharges would exceed the capacity at S-333. This would result in larger flows in the western half of the flow-way that could cause an easterly direction of flow in NESRS. Also, the general goal of achieving a 45/55 split of flows to SRS and NESRS could not be accomplished.

Consequently, even a portion of the hydrologic objectives south of Tamiami Trail could not be accomplished through Phase 1. Enlargement of S-333 and the L-29 borrow canal would be required to accomplish the hydrologic objectives. However, these additional works would not be required when Phase 2 is constructed. Even if the hydrologic goals could be fully accomplished south of Tamiami Trail, there would be a significant risk that the ecological objectives would not be satisfied. WCA No. 3B was historically an important nesting site for wading birds. With only Phase 1 implemented, WCA No. 3B would continue to be poor quality habitat for wading bird nesting.

Therefore, it is recommended that this project be implemented as a whole rather than through phased construction. Furthermore, SFWMD and ENP have indicated that they would not support an alternative that does not include the improvements proposed for the WCA's.

T. RECOMMENDATIONS

91. General. Recommend the proposed plan be approved for construction of three culvert structures (S-345A, S-345B, and S-345C); three gated concrete headwall structures (S-349A, S-349B, and S-349C); three spillways (S-355A and S-355B, and S-334); two pump stations (S-356 and S-357); raising U.S. 41; degrading L-67 Extension; flood mitigation in the residential area; flood mitigation of an airboat camp; flood mitigation of two Miccosukee Indian Camps; mitigation of recreational boating in the L-67A borrow canal; and monitoring of the project's impact on the adjacent agricultural area of the East Everglades as prescribed in PL 101-229. The recommended plan is described in Section J of this report.

92. The minimum water delivery requirements of PL 91-282 will no longer be the basis of delivery but will be superseded by the schedules developed by the Secretary of the Army. An initial operating plan for the project features will be developed through a continuing process of studies and coordination. Such a plan should be developed by the Secretary of the Army in consultation with the Secretary of Interior and the State of Florida prior to completion of construction. As additional knowledge is gained through experience with the interim operating plan and data collection, subsequent changes to the operating plan should be made, as appropriate, by the Secretary of the Army, in consultation with the Secretary of Interior and the State of Florida, through a continuing iterative testing process.

The iterative process will include hydrologic modeling and coordination to develop an acceptable water control plan. The process will be conducted concurrently with detailed engineering and design studies and construction of the project's structural features. The operational studies will consist of hydrologic modeling, coordination of modeling results, and environmental evaluations. This process will include re-initiation of endangered species consultation and preparation of either a supplement to the Environmental Impact Statement (EIS) or an Environmental Assessment and Finding of No Significant Impact (FONSI).

If an acceptable operational strategy has not been developed at the end of the iterative process, the Modified Rain-Driven Operational strategy addressed in this report will be the water control plan implemented when construction of the structural features is complete. Regardless of which water control plan is initially adopted, review and adjustment of project operations will continue as experience and assessment of additional data reveal potential for improvement.

93. In addition, recommend that monitoring of the endangered snail kite for quantifying movements, survival and reproductive success by banding and radio telemetry be conducted and funded by the Department of the Interior, U.S. Fish and Wildlife Service, through its normal budgetary process. Estimated cost of the monitoring program, over a five year period, is about $400,000. Furthermore, that monitoring of hydrologic parameters be conducted for correlation with endangered species in the WCA No. 3A area.

94. Furthermore, recommended that the project be constructed, operated, and maintained under the following terms of local cooperation:

a. Contribute a minimum of 25 percent of total O&M costs needed to operate, maintain, repair, replace, and rehabilitate the project works involved to prevent an increased risk of flooding in the residential area including the levee and canal system, the pumping stations, and the structural works and modifications in the Water Conservation Area No. 3 and adjacent canals;

b. Hold and save the United States free from damages due to the construction or subsequent maintenance of the project, except any damages due to the fault or negligence of the United States or its contractors;

c. Prevent encroachment on the flood-carrying capacity of the project including the culvert system under the U.S. 41 road; and,

d. Maintain and operate the works after completion according to regulations prescribed by the Secretary of the Army, except the water control structures and outlets in Water Conservation Area No. 3, which will be maintained and operated by the Corps of Engineers.

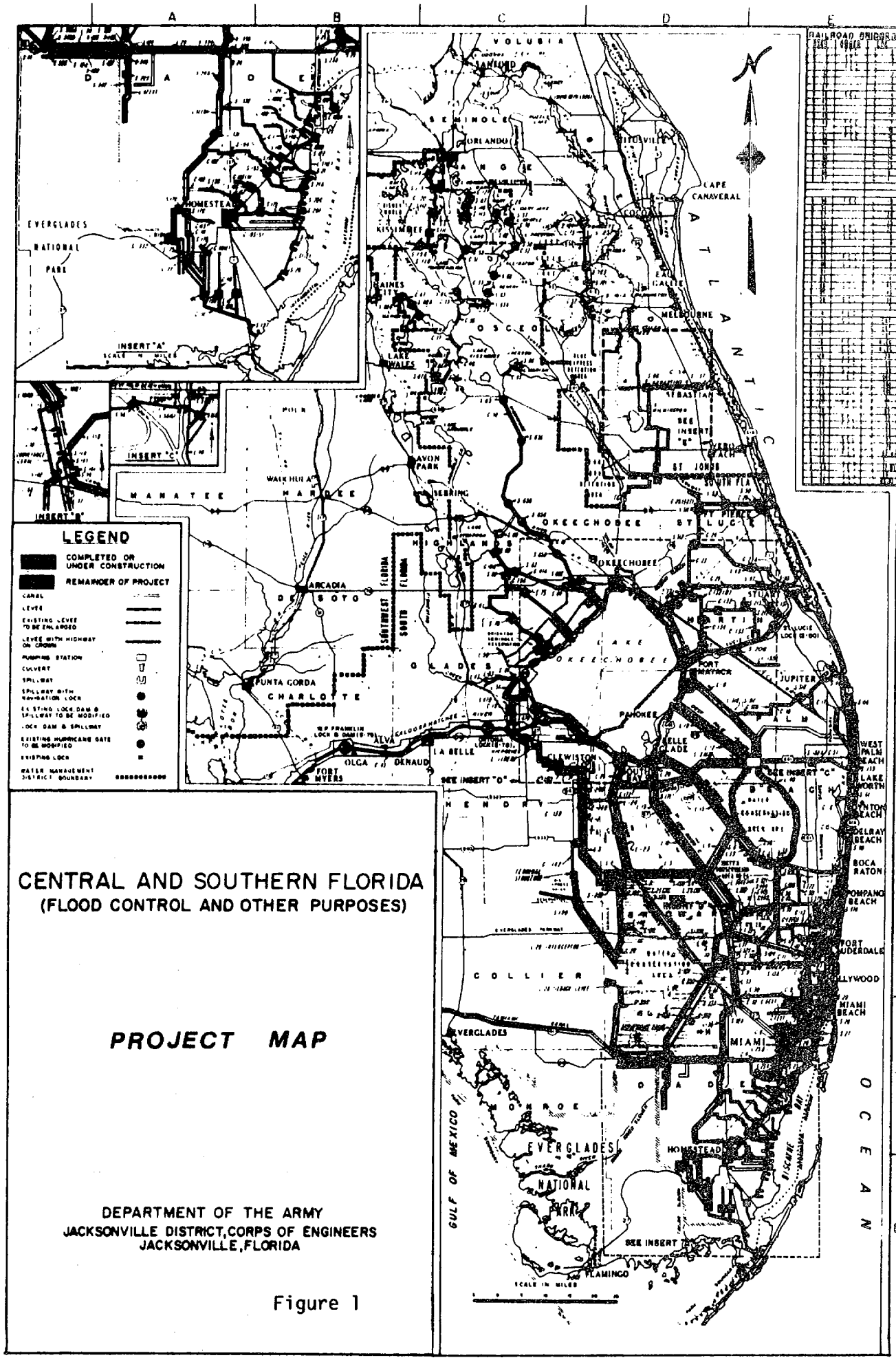
TERRENCE C. SALT
Colonel, Corps of Engineers
Commanding

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

PART I

AGRICULTURAL AND CONSERVATION AREAS
SUPPLEMENT 54 - GENERAL DESIGN MEMORANDUM
MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

FIGURES



CENTRAL AND SOUTHERN FLORIDA
(FLOOD CONTROL AND OTHER PURPOSES)

PROJECT MAP

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

Figure 1

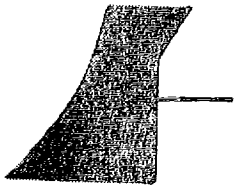
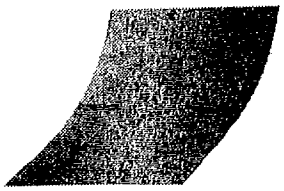
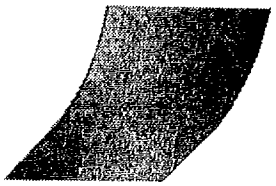
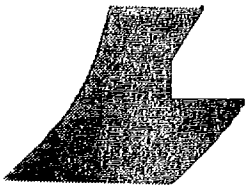
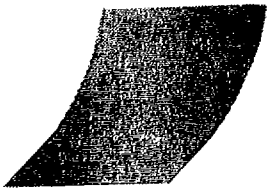
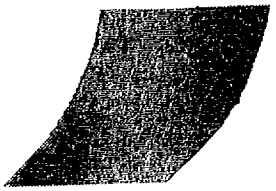
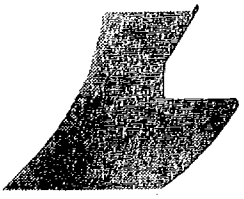
PLAN/CONDITION	LOCATION	TIMING & VOLUME
Objective		a. Fluctuate in response to rainfall/evaporation b. Minimize sudden changes due to other project purposes c. Maintain water supply/ flood control capability
Without		a. Fluctuate according to prescribed schedule b. Sudden changes occur due to flood control operations c. Water supply/flood control capabilities maintained
Flow-Through		a. fluctuates in response to rainfall/evapotranspiration b. Sudden water management changes do not occur c. Water supply adversely impacted due to overdrainage of WCA 3A
Rain Driven		a. Fluctuates in response to rainfall/evapotranspiration b. Sudden water management changes do not occur c. Water supply/flood control capabilities not impacted
Restricted Rain Driven		a. Limitations in fluctuations under wet conditions b. Sudden water management changes are reduced c. Water supply/flood control capabilities not impacted
Basic Rain Driven		a. Fluctuates in response to rainfall/evaporation b. Sudden water management conditions do not occur c. Water supply/flood control capacities not impacted
Modified Rain Driven		a. Fluctuates in response to rainfall/evapotranspiration, except in drought b. Sudden water management changes do not occur c. Water supply in EAA could be impacted
Modified Minimum Deliveries		a. Limited fluctuations due to structural limitations b. Sudden water management changes do not occur c. Water supply/flood control capacities not impacted

Figure 2

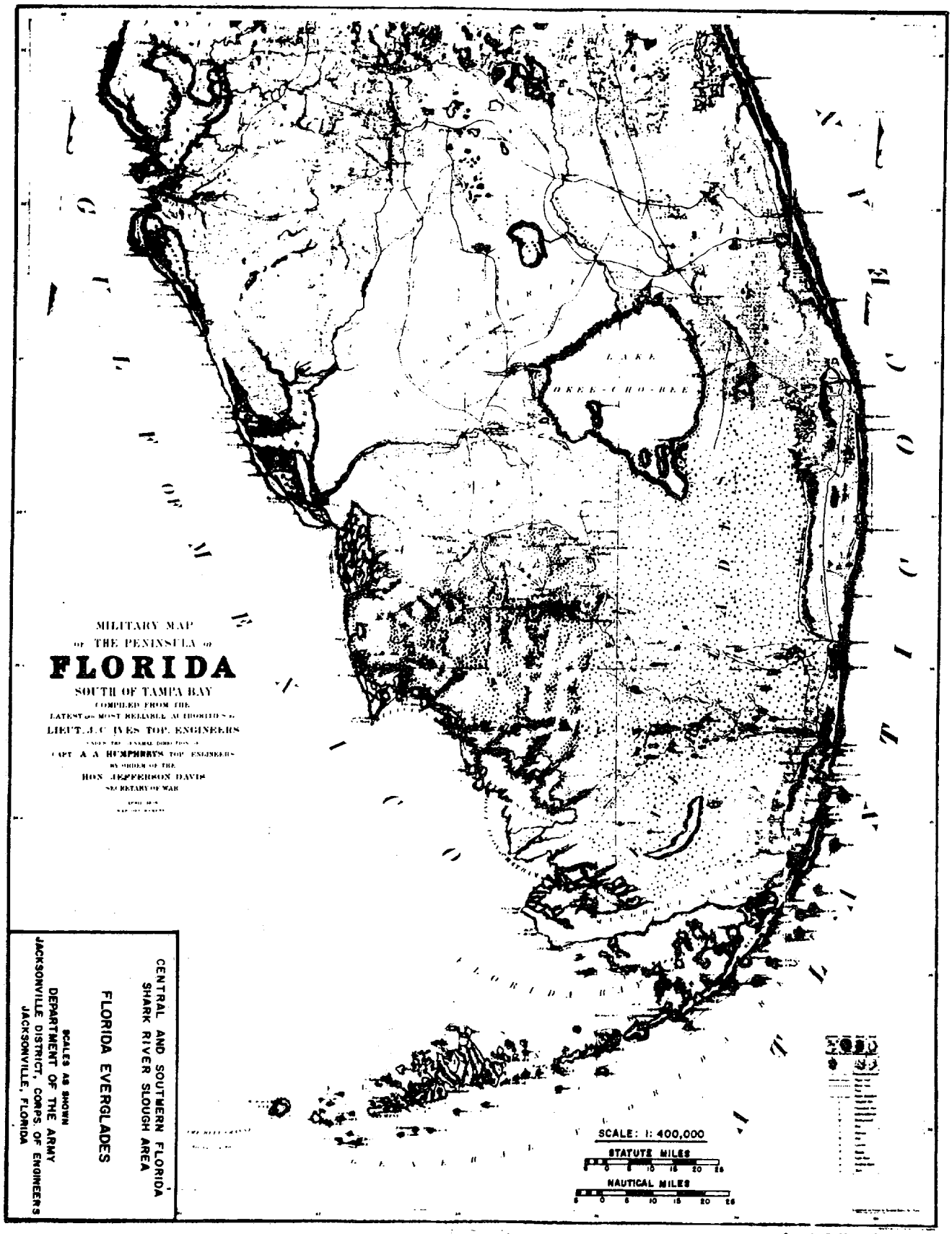

MILITARY MAP
OF THE PENINSULA OF
FLORIDA
SOUTH OF TAMPA BAY
COMPILED FROM THE
LATEST AND MOST RELIABLE AUTHORITIES BY
LIEUT. J.C. IVES TOP. ENGINEERS
UNDER THE GENERAL DIRECTION OF
CAPT. A.A. HUMPHREYS TOP. ENGINEERS
BY ORDER OF THE
HON. JEFFERSON DAVIS
SECRETARY OF WAR
LAKE
OKEE-CHO-BEE
SCALE: 1: 400,000
STATUTE MILES
NAUTICAL MILES
CENTRAL AND SOUTHERN FLORIDA
SHARK RIVER SLOUGH AREA
FLORIDA EVERGLADES
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

Figure 3

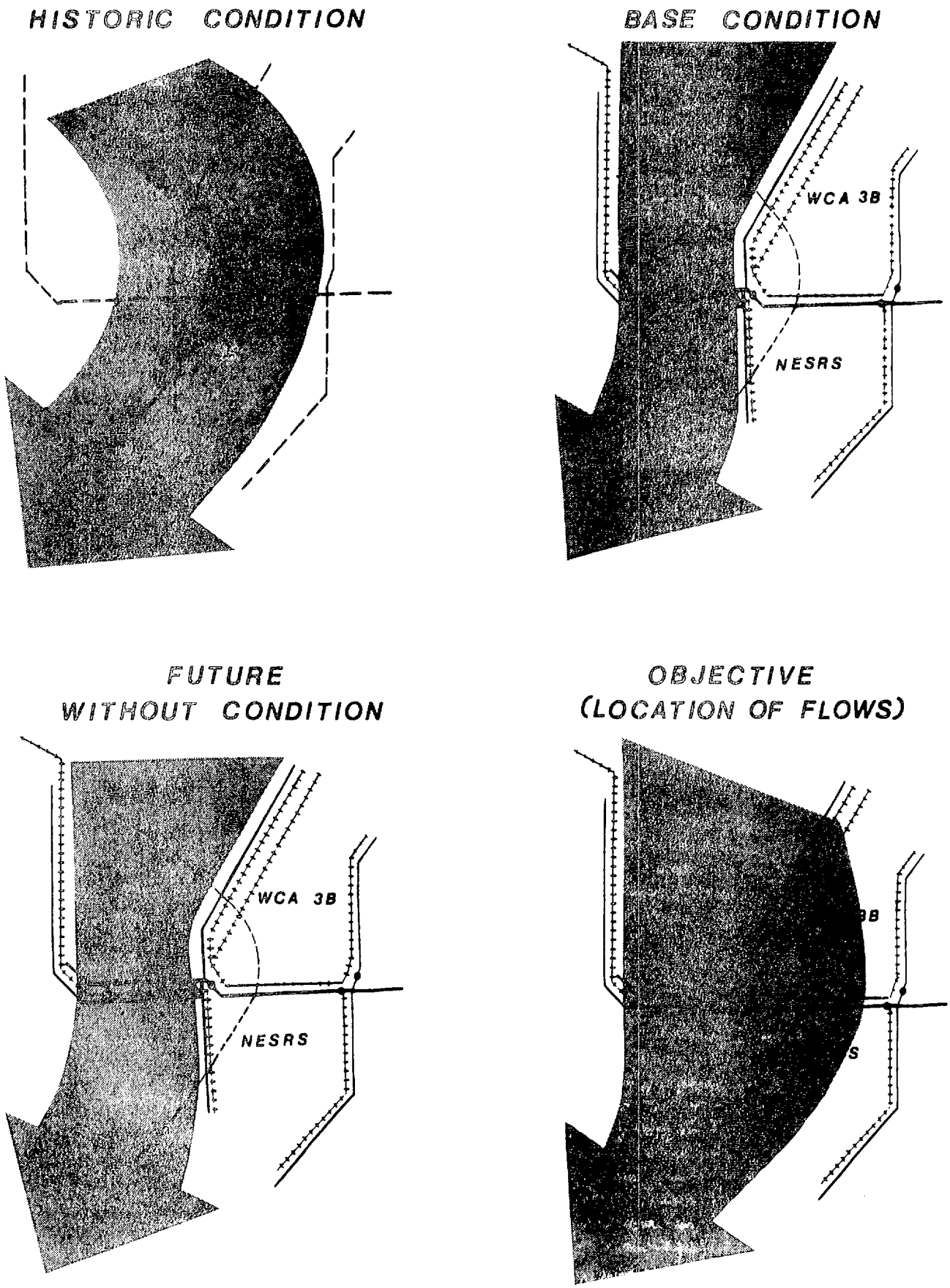

HISTORIC CONDITION
BASE CONDITION
WCA 3B
NESRS
FUTURE
WITHOUT CONDITION
WCA 3B
NESRS
OBJECTIVE
(LOCATION OF FLOWS)

Figure 4

WATER CONSERVATION AREAS

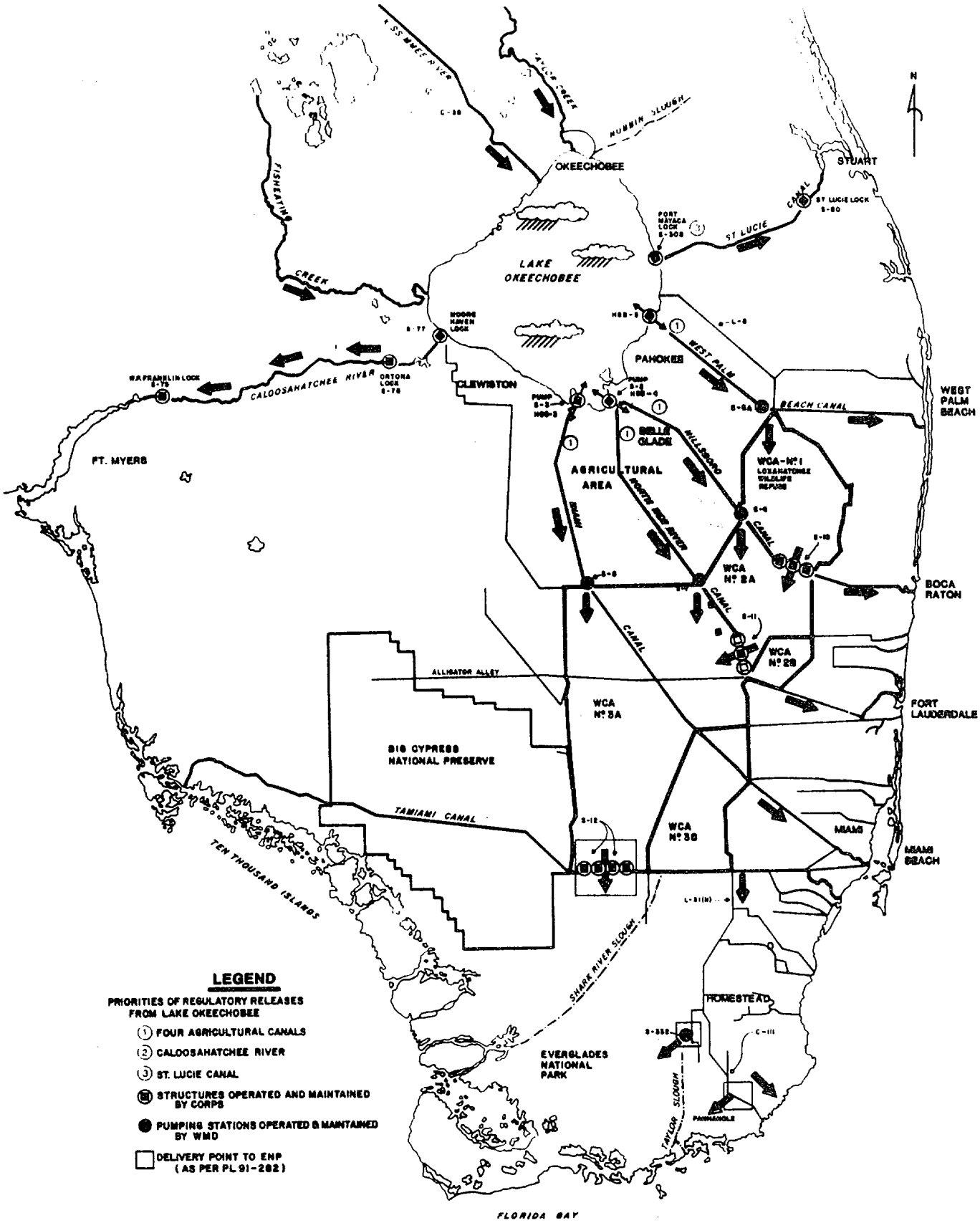
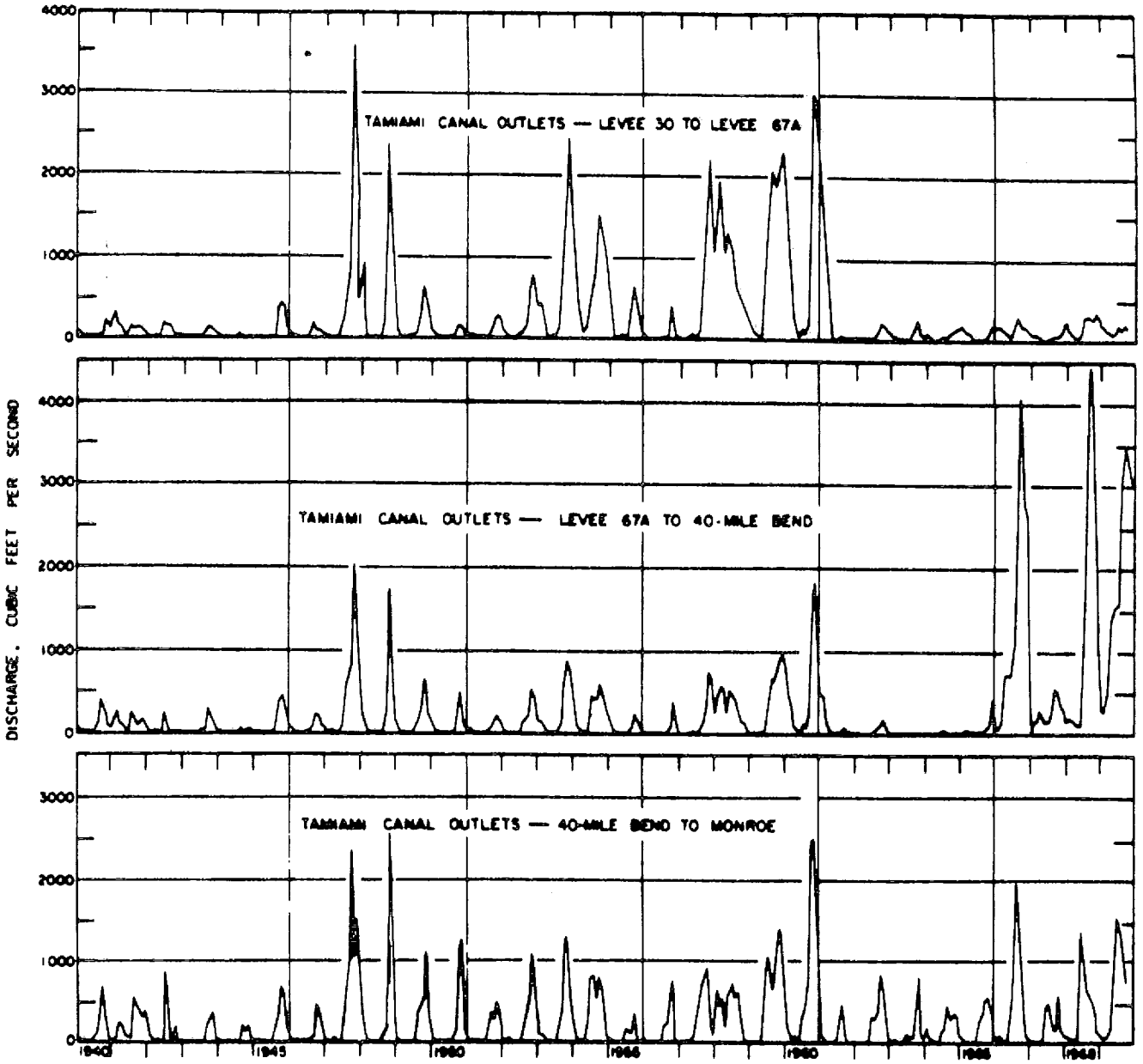
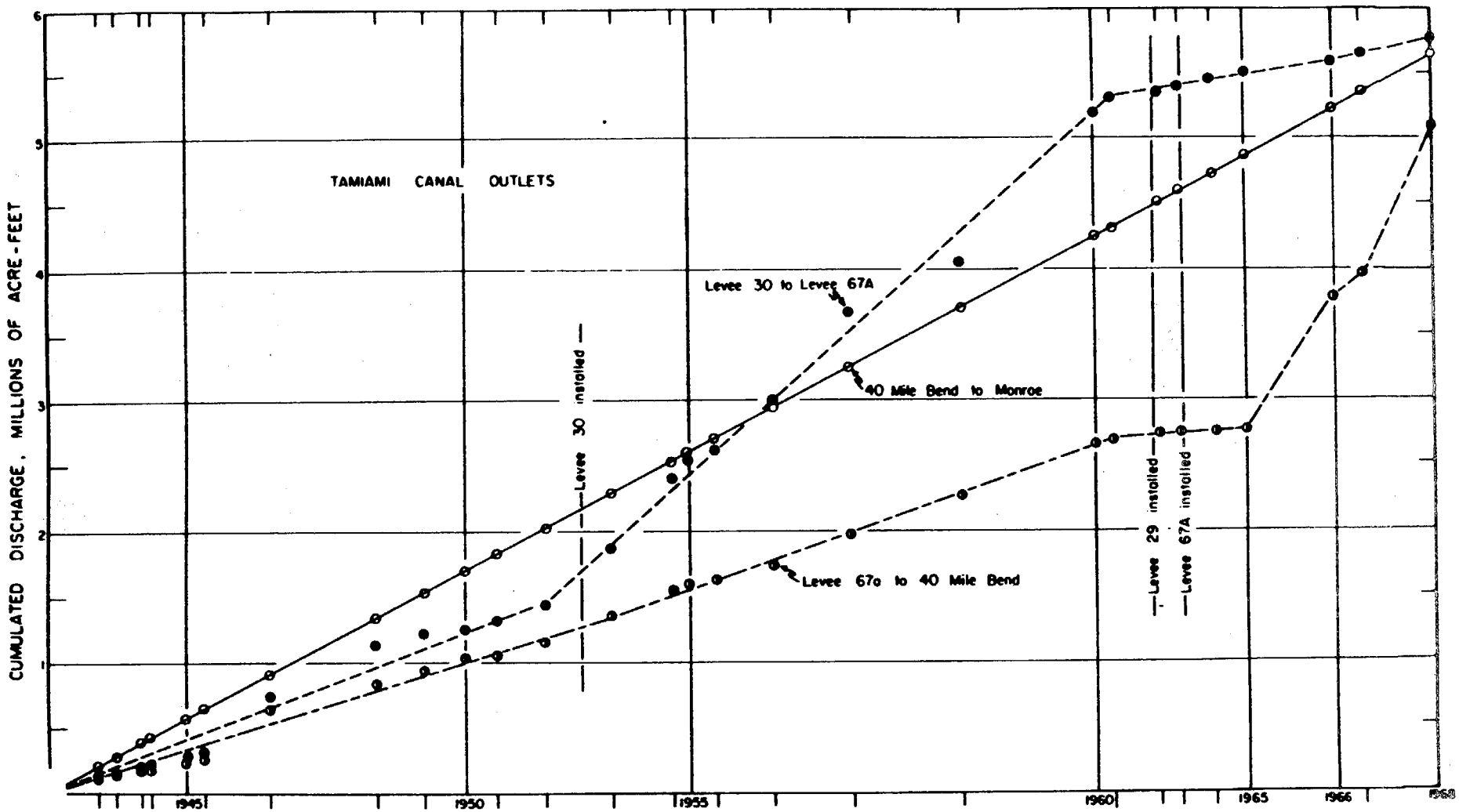


Figure 5



Monthly mean discharge of the Tamiami Canal outlets, Levee 30 to Monroe, Florida, subdivided into three sections, 1941-69

Figure 6



Cumulative annual discharge showing the effects of construction on each of the three sections of the Tamiami Canal outlets between Levee 30 and Monroe, Florida

Figure 7

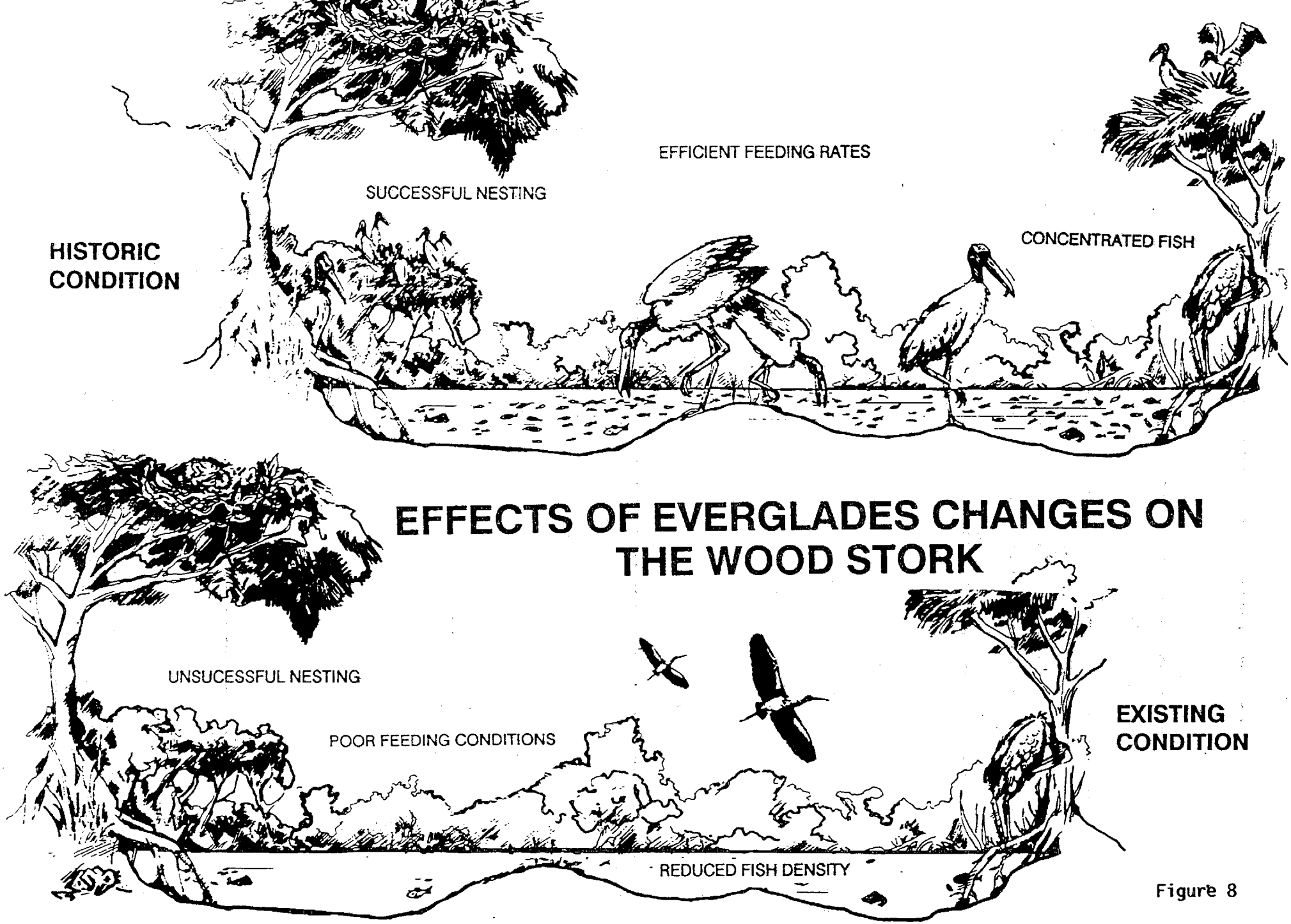
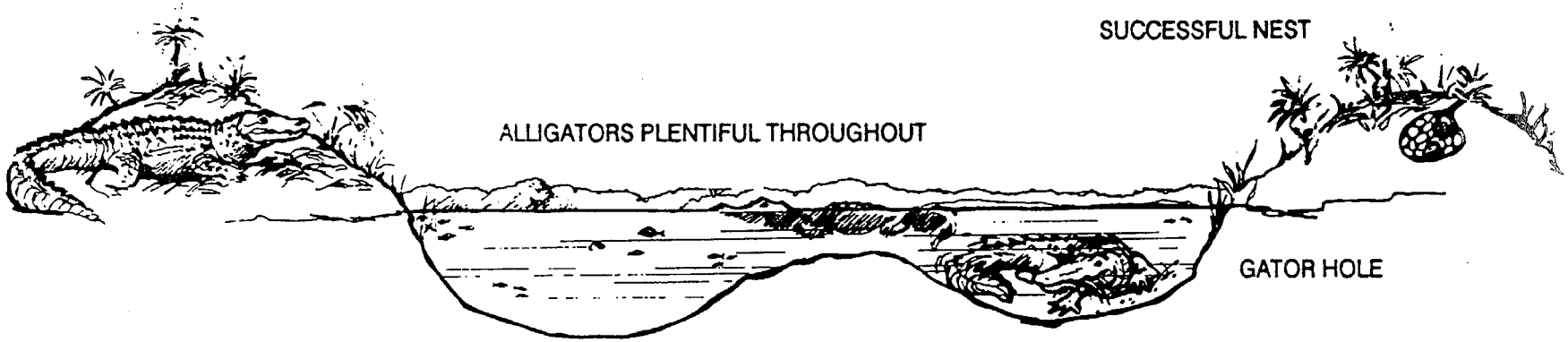

EFFECTS OF EVERGLADES CHANGES ON THE WOOD STORK
HISTORIC CONDITION
SUCCESSFUL NESTING
EFFICIENT FEEDING RATES
CONCENTRATED FISH
EXISTING CONDITION
UNSUCESSFUL NESTING
POOR FEEDING CONDITIONS
REDUCED FISH DENSITY

Figure 8

West Shark River Slough

East Shark River Slough

HISTORIC CONDITION



EFFECTS OF EVERGLADES CHANGES ON THE ALLIGATOR

EXISTING CONDITION

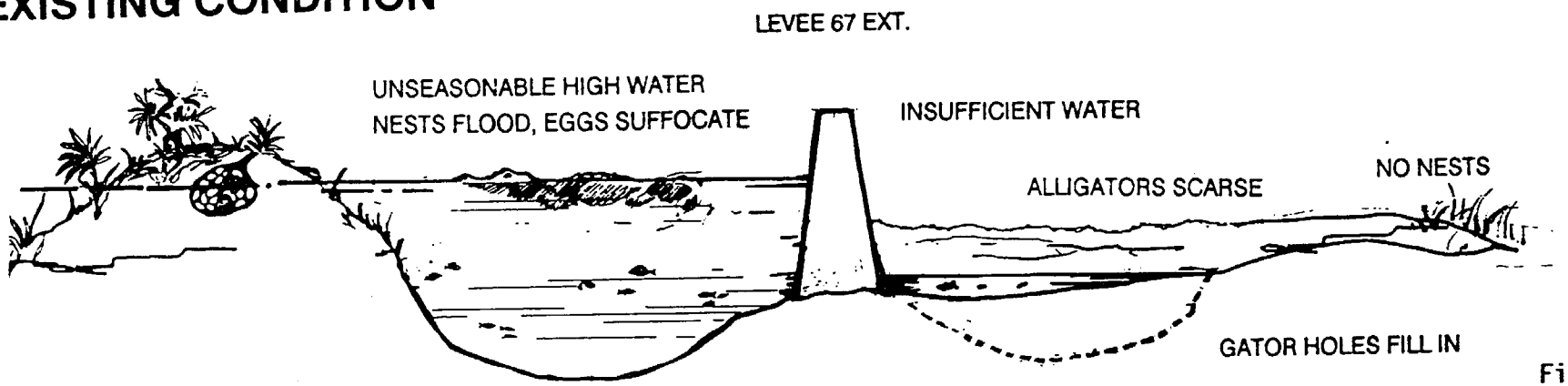


Figure 9

FIGURE 10

RAIN–DRIVEN WATER DELIVERIES

WCA NO. 3A STRUCTURE OPERATIONS

	S–12	S–333	S–151	S–345	S–343&	S–355
ZONE A	OPEN FULL	MAXIMUM ALLOWABLE DISCHARGE	MAXIMUM ALLOWABLE DISCHARGE	MAXIMUM ALLOWABLE DISCHARGE	OPEN FULL	OPEN FULL
ZONE B	SAME AS ZONE A	DISCHARGE ADDITIONAL FLOWS NEEDED TO PASS 55% OF COMPUTED FLOW WHEN S–355 CAPACITY IS NOT ADEQUATE	DISCHARGES TO WCA 3B IF DESIRED OR WATER SUPPY DISCHARGES TO CONVEYANCE SYSTEM	SAME AS ZONE A	OPEN FULL IF NO PROBLEMS	DISCHARGE 55% OF COMPUTED FLOW FOR SHARK RIVER SLOUGH
ZONE C	DISCHARGE 45% OF COMPUTED FLOW FOR SHARK RIVER SLOUGH	SAME AS ZONE B OR WATER SUPPLY TO CONVEYANCE SYSTEM	SAME AS ZONE B	SAME AS ZONE A	CAN BE OPENED FOR WATER SUPPLY TO BIG CYPRESS	SAME AS ZONE B
ZONE D	SAME AS ZONE C	SAME AS ZONE C	WATER SUPPLY DISCHARGES TO CONVEYANCE SYSTEM AS NEEDED	BEGIN DISCHARGE AT BOTTOM AND LINEARILY INCREASE TO 1500 CFS AT TOP OF ZONE	CLOSED	SAME AS ZONE B
ZONE E	SAME AS ZONE C	SAME AS ZONE C	SAME AS ZONE D	BEGIN DISCHARGE 0.5 FT BELOW ZONE C AND LINEARILY INCREASE TO 1,500 CFS AT BOTTOM OF ZONE C	SAME AS ZONE D	SAME AS ZONE B

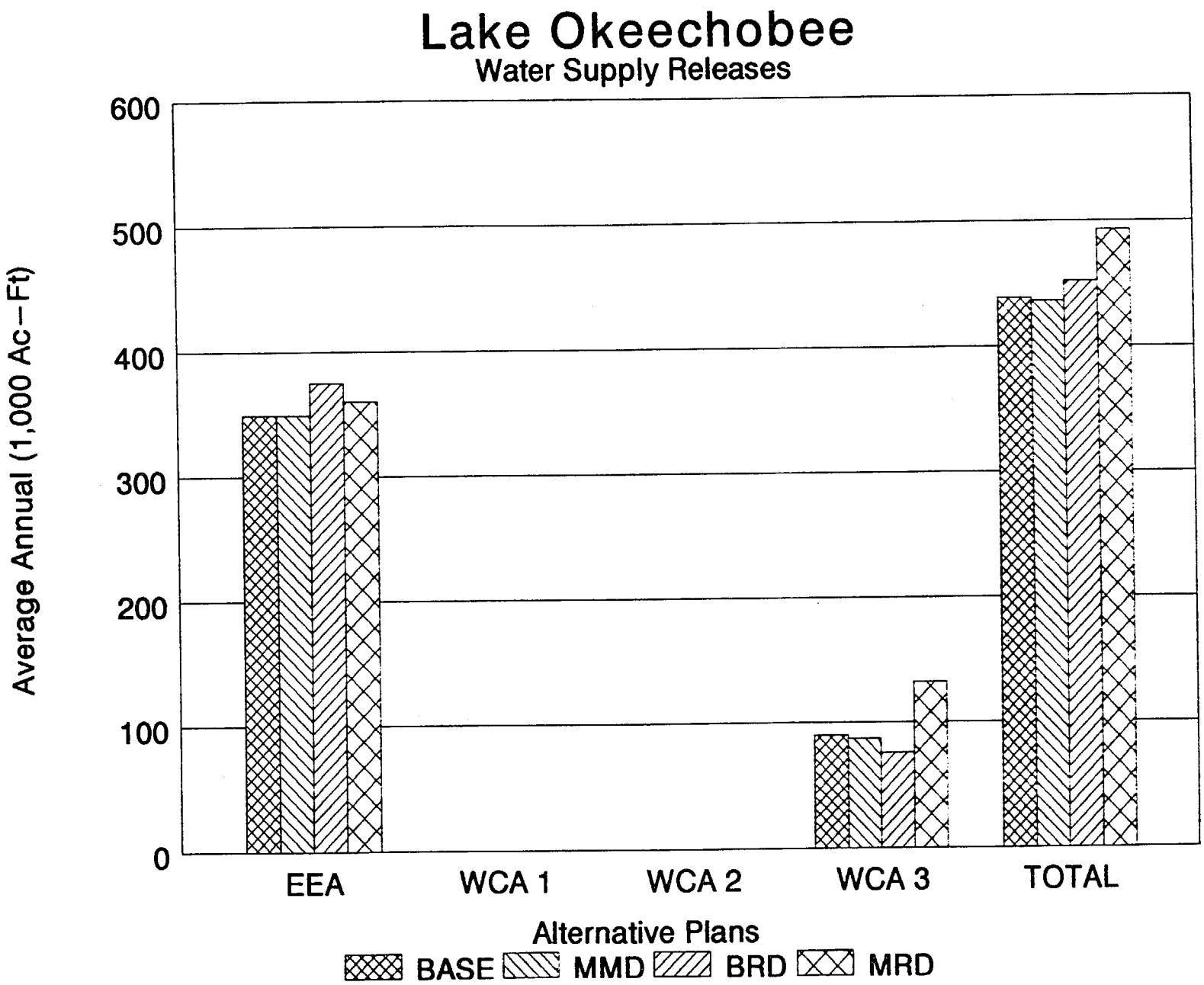
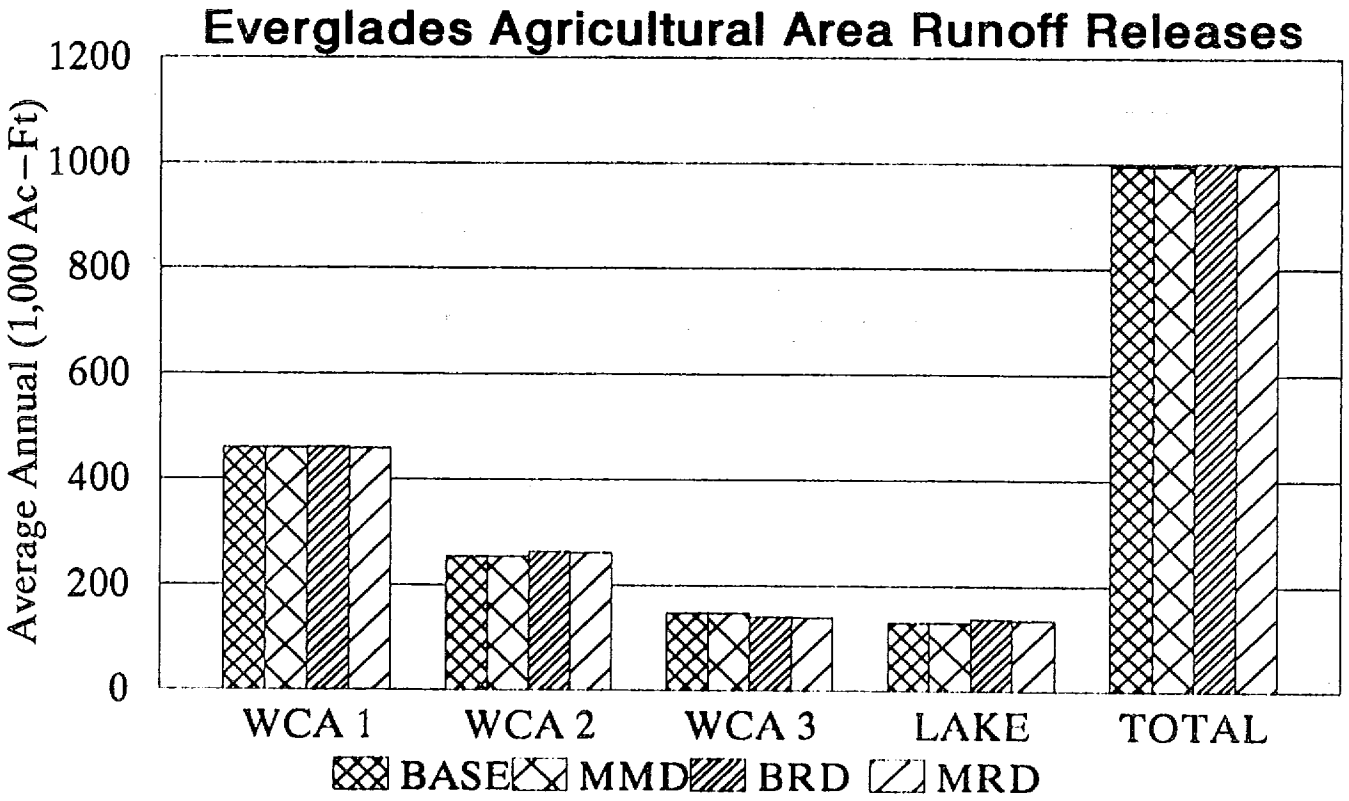

Lake Okeechobee
Water Supply Releases
Average Annual (1,000 Ac–Ft)
600
500
400
300
200
100
0
EEA
WCA 1
WCA 2
WCA 3
TOTAL
Alternative Plans
BASE
MMD
BRD
MRD

FIGURE 11


Everglades Agricultural Area Runoff Releases
Average Annual (1,000 Ac-Ft)
1200
1000
800
600
400
200
0
WCA 1
WCA 2
WCA 3
LAKE
TOTAL
BASE
MMD
BRD
MRD

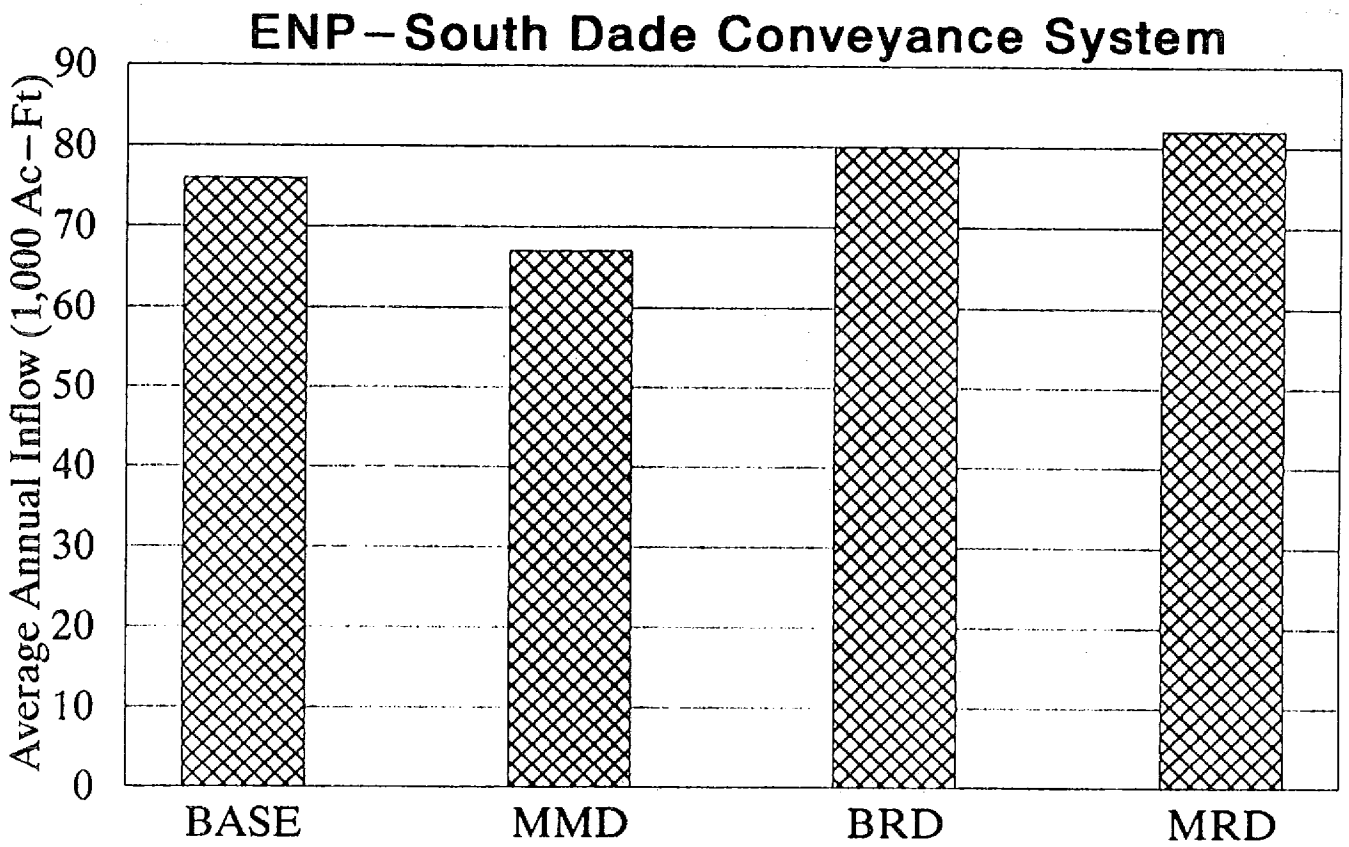
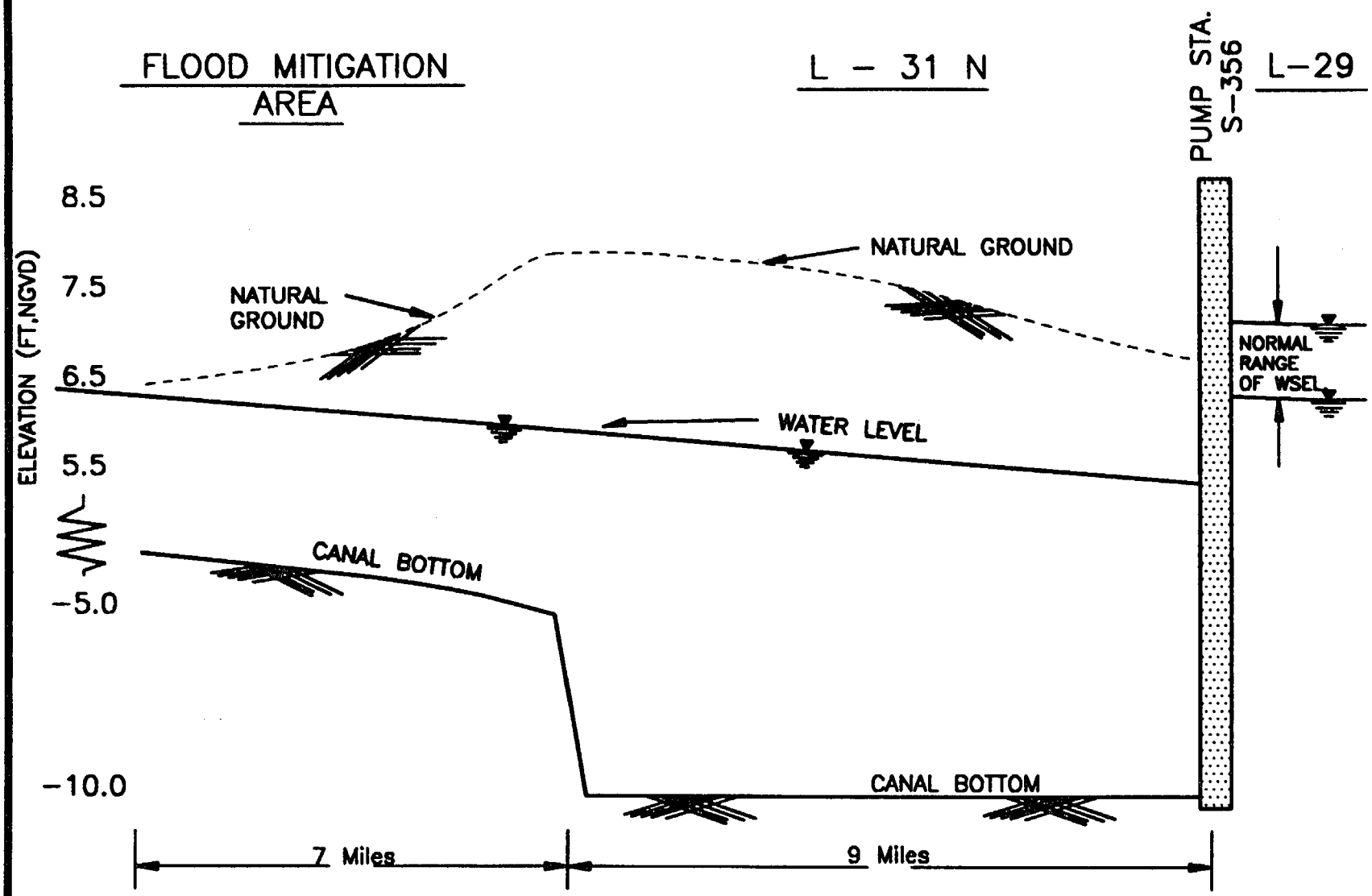

ENP-South Dade Conveyance System
Average Annual Inflow (1,000 Ac-Ft)
90
80
70
60
50
40
30
20
10
0
BASE
MMD
BRD
MRD

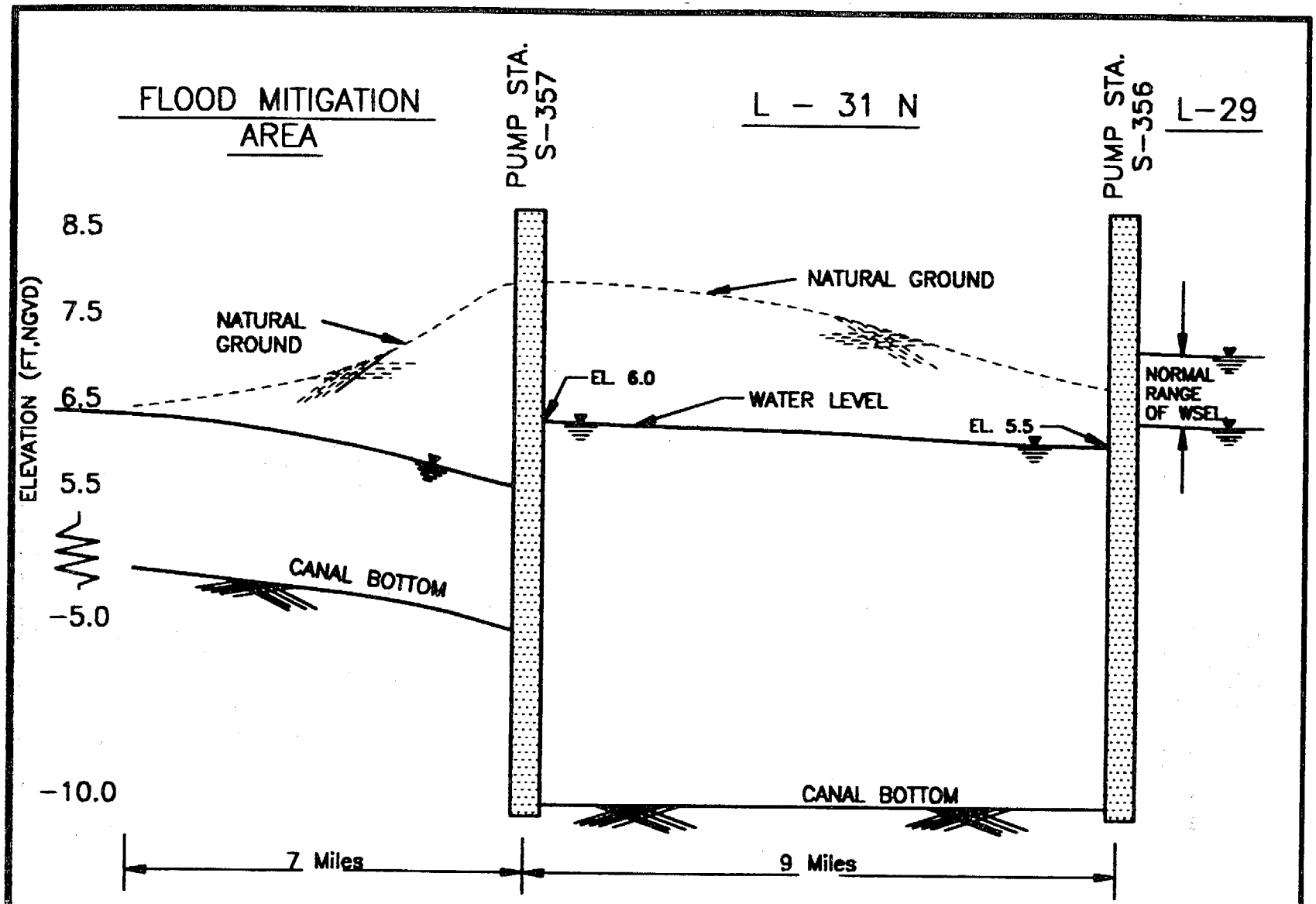
FIGURE 12



SINGLE PUMP STATION
WATER LEVEL PROFILE

NOT TO SCALE

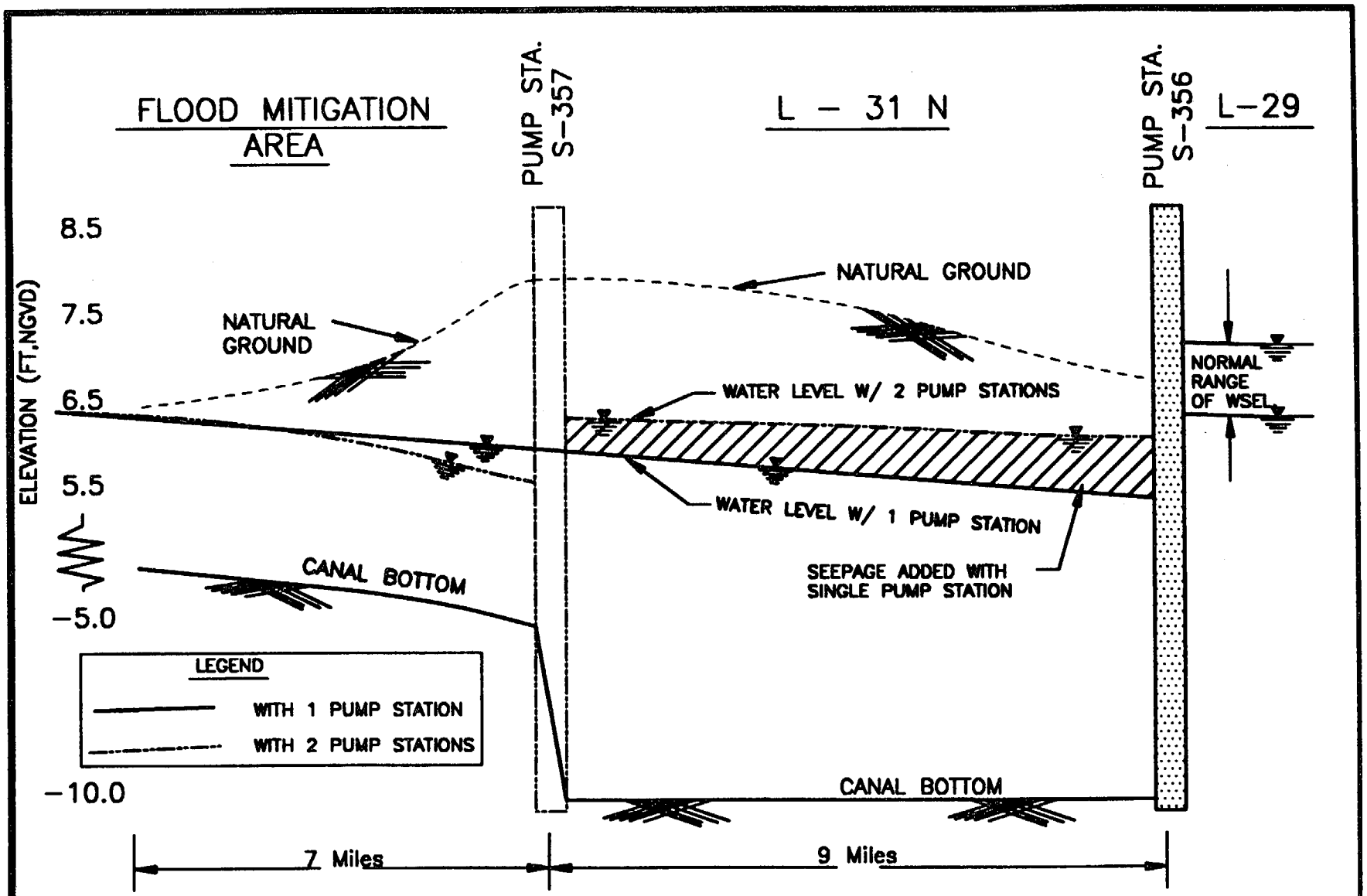
FIGURE 13



DOUBLE PUMP STATION
WATER LEVEL PROFILE

NOT TO SCALE

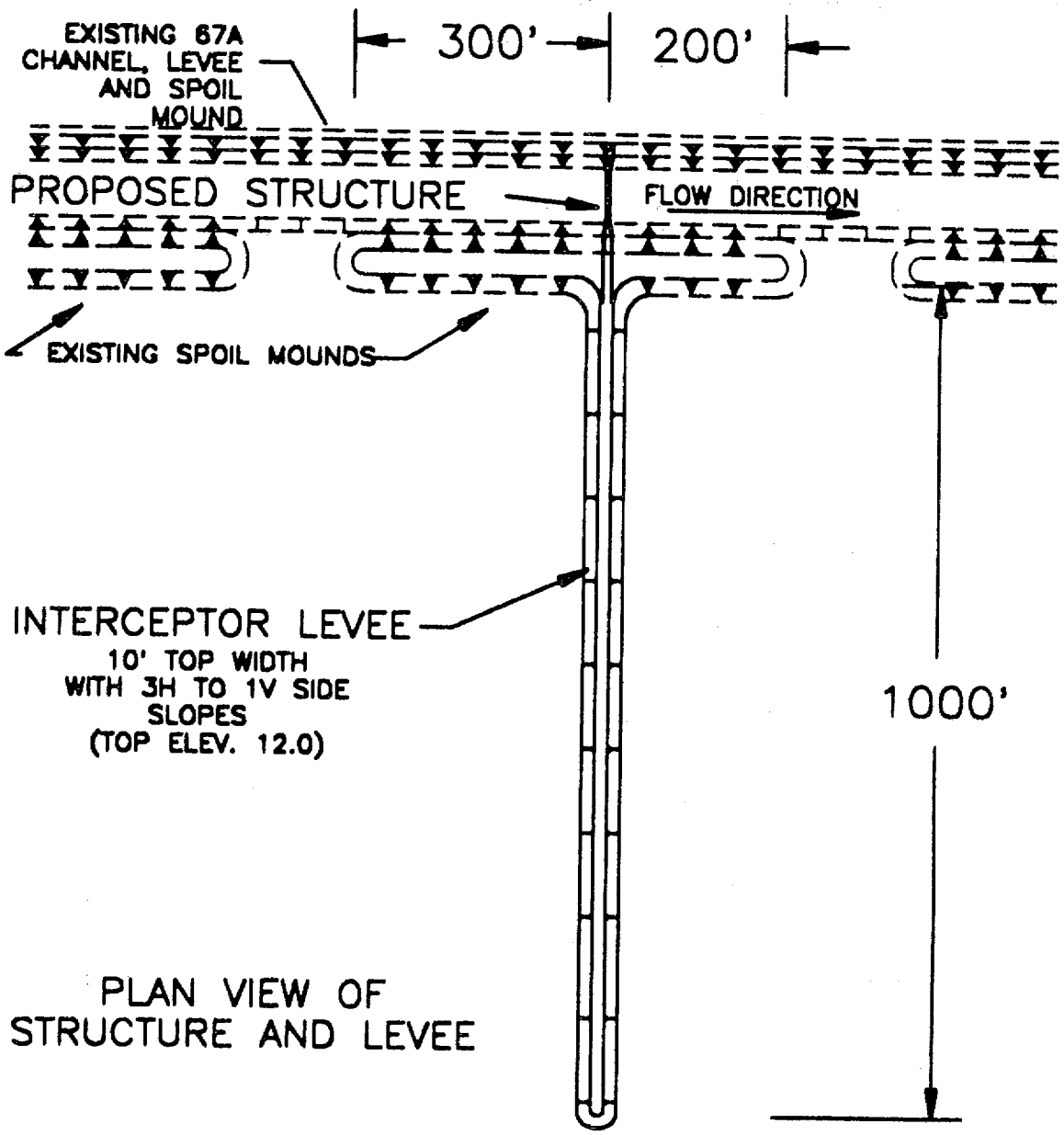
FIGURE 14



COMPARSION OF SINGLE AND DOUBLE PUMP STATIONS
WATER LEVEL PROFILE

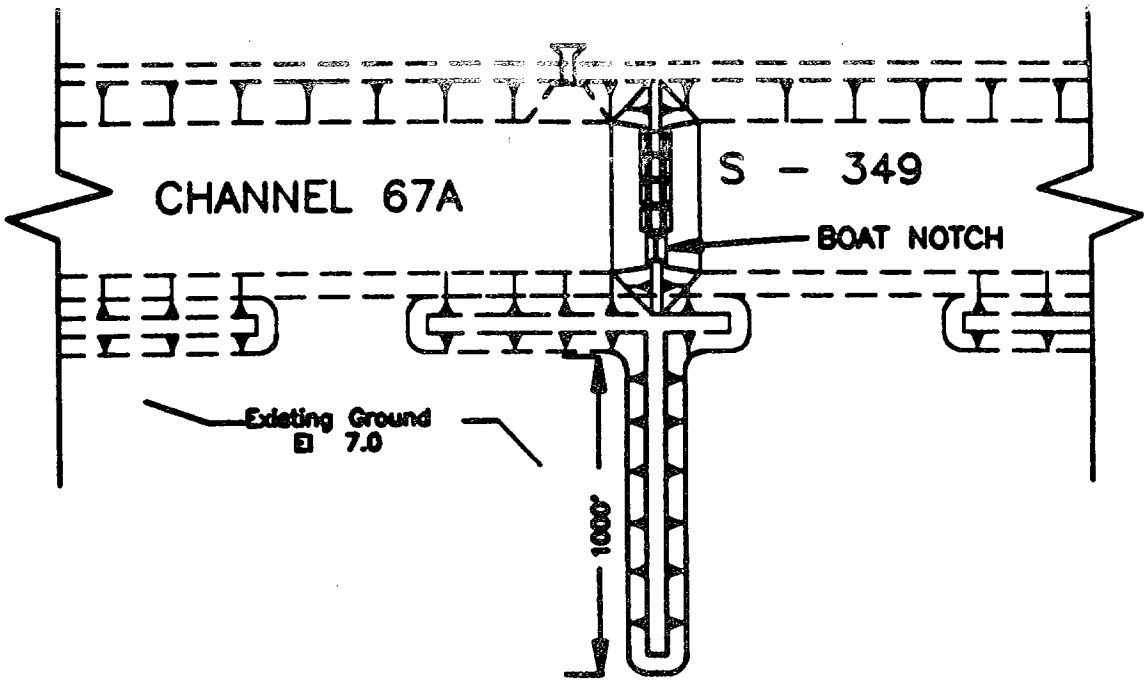
FIGURE 15

NOT TO SCALE

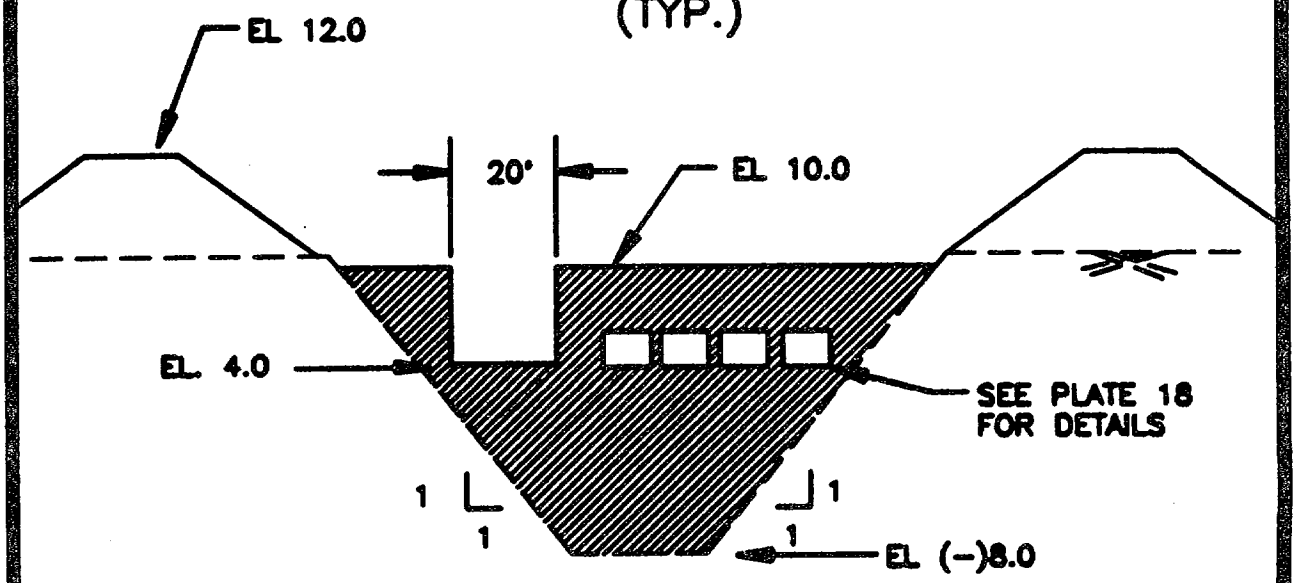


STRUCTURE S-349 WITHOUT BOATING ACCESS

FIGURE 16



PLAN VIEW
(TYP.)

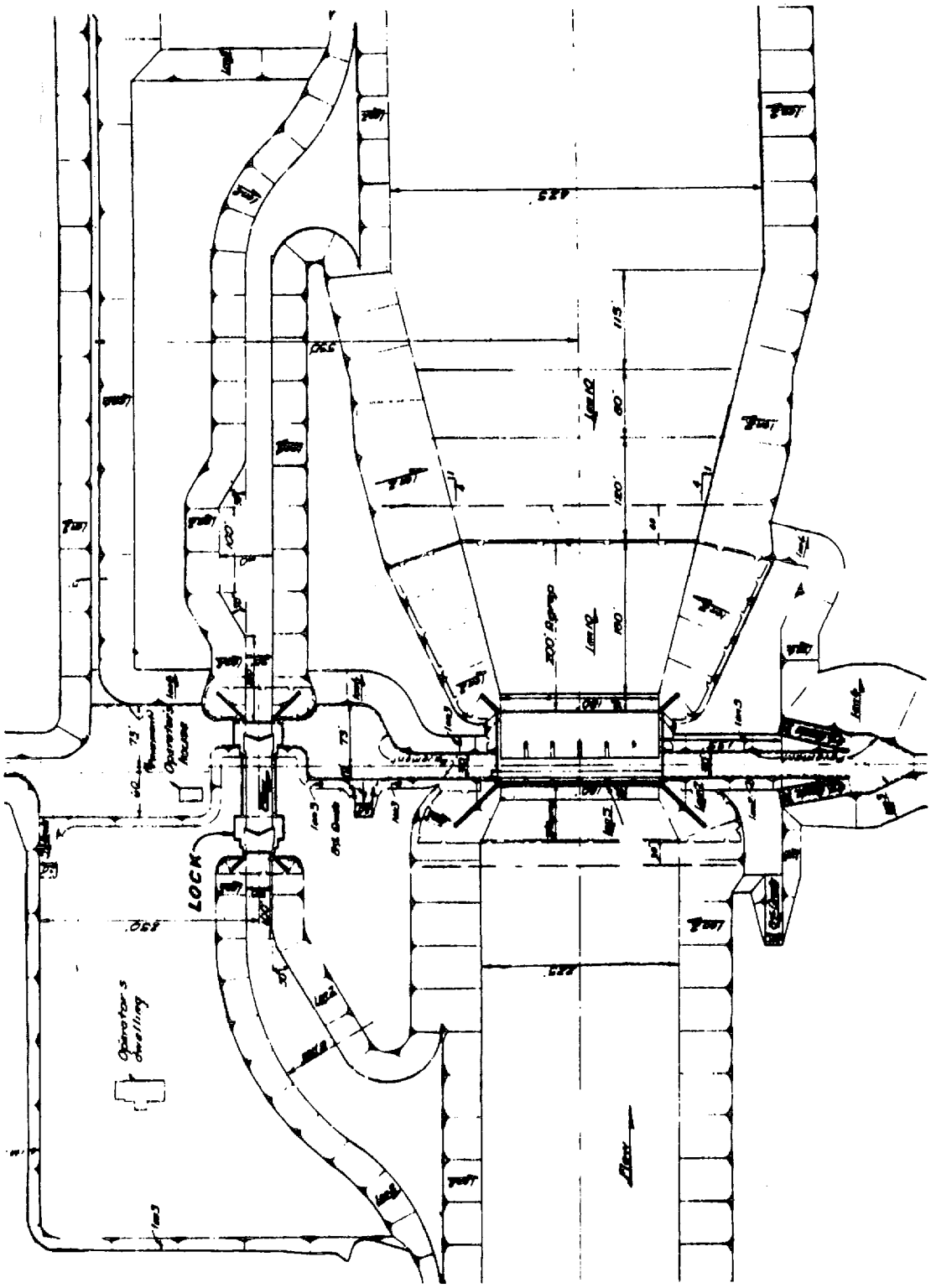


BOAT NOTCH
SECTION

BOAT NOTCH OPTION

TOTAL OF THREE
ONLY ONE SHOWN

FIGURE 17

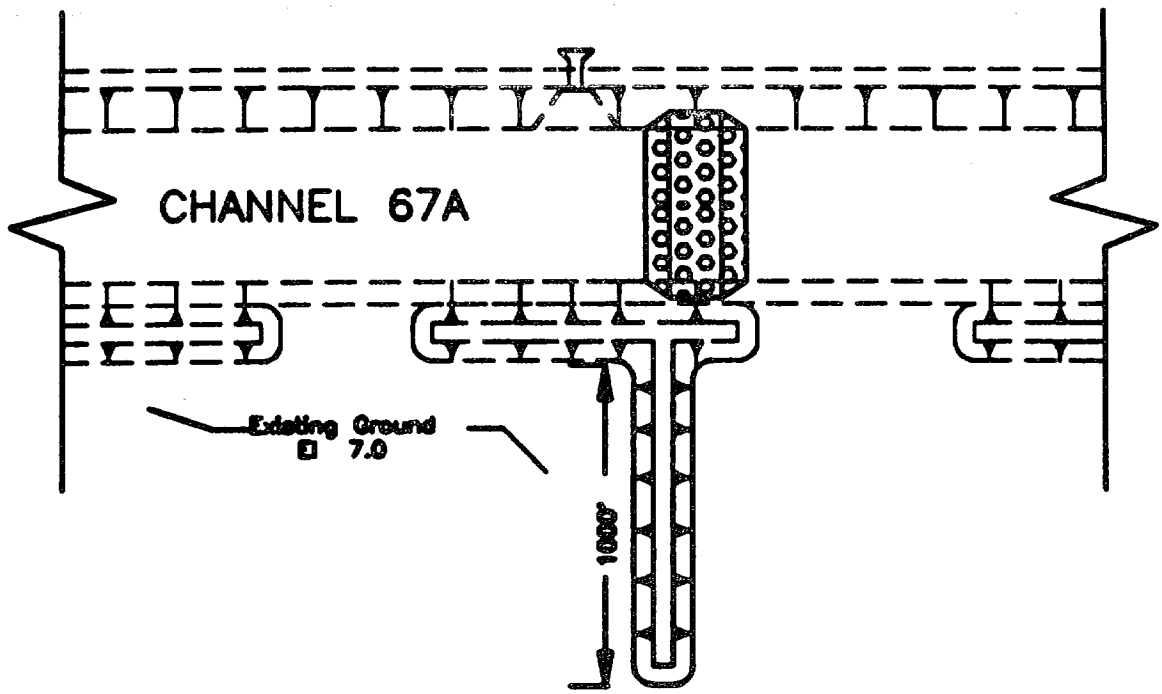


SITE PLAN

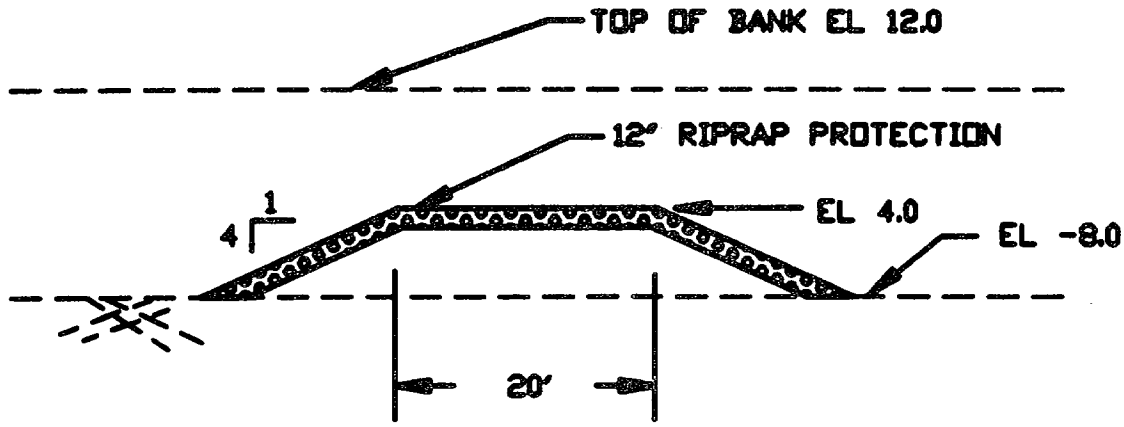
SCALE IN FEET

BOAT LOCK OPTION

FIGURE 18



PLAN VIEW
(TYP.)



PROFILE SECTION

PARTIAL PLUG OPTION

TOTAL OF THREE
ONLY ONE SHOWN

FIGURE 19

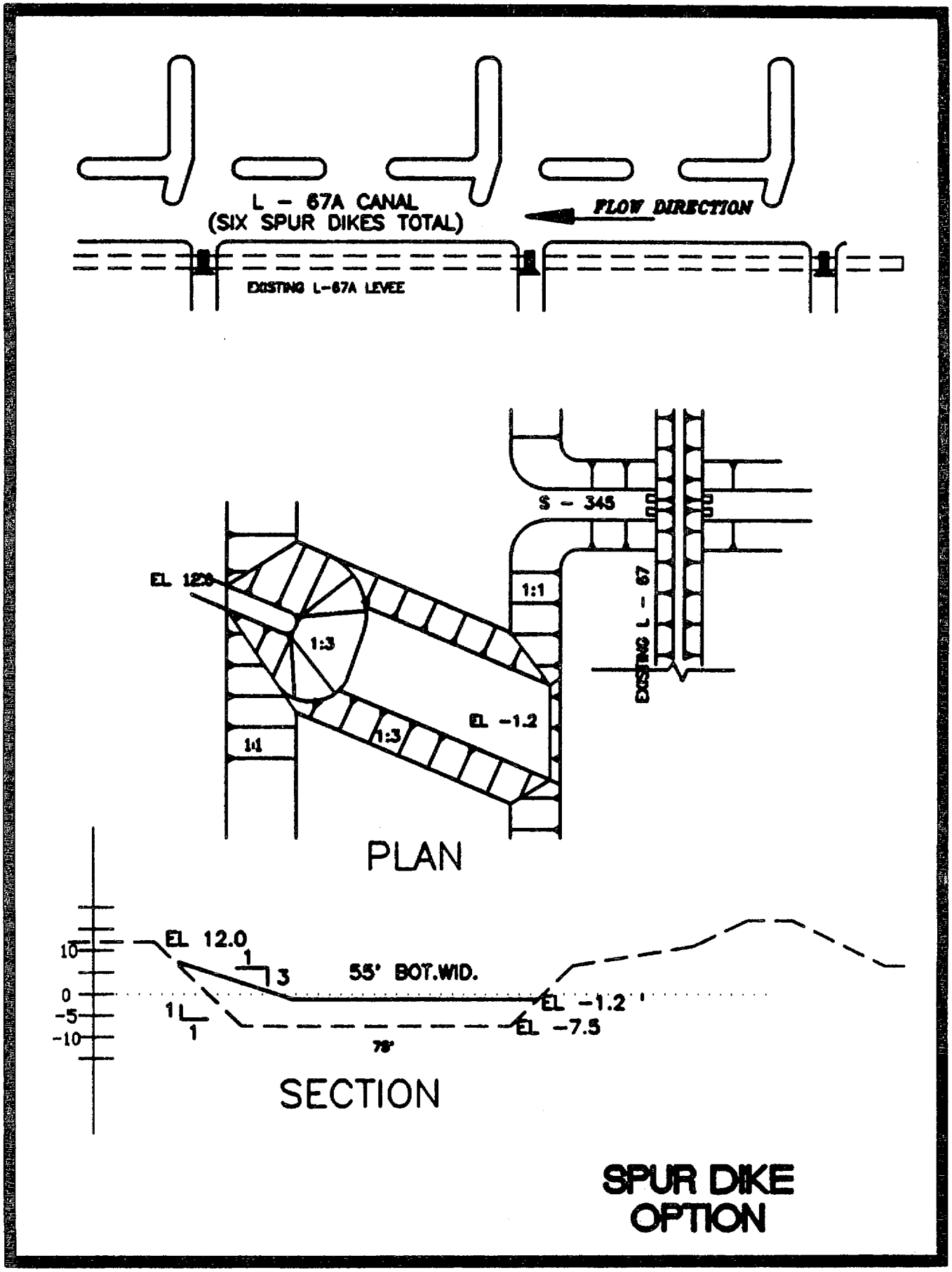

L - 67A CANAL
(SIX SPUR DIKES TOTAL)
FLOW DIRECTION
EXISTING L-67A LEVEE
S - 345
EL 12.0
1:1
1:3
EL -1.2
1:1
1:3
EXISTING L - 67
PLAN
EL 12.0
1
3
55' BOT.WID.
10
0
-5
-10
1
1
EL -1.2
EL -7.5
78'
SECTION
SPUR DIKE
OPTION

FIGURE 20

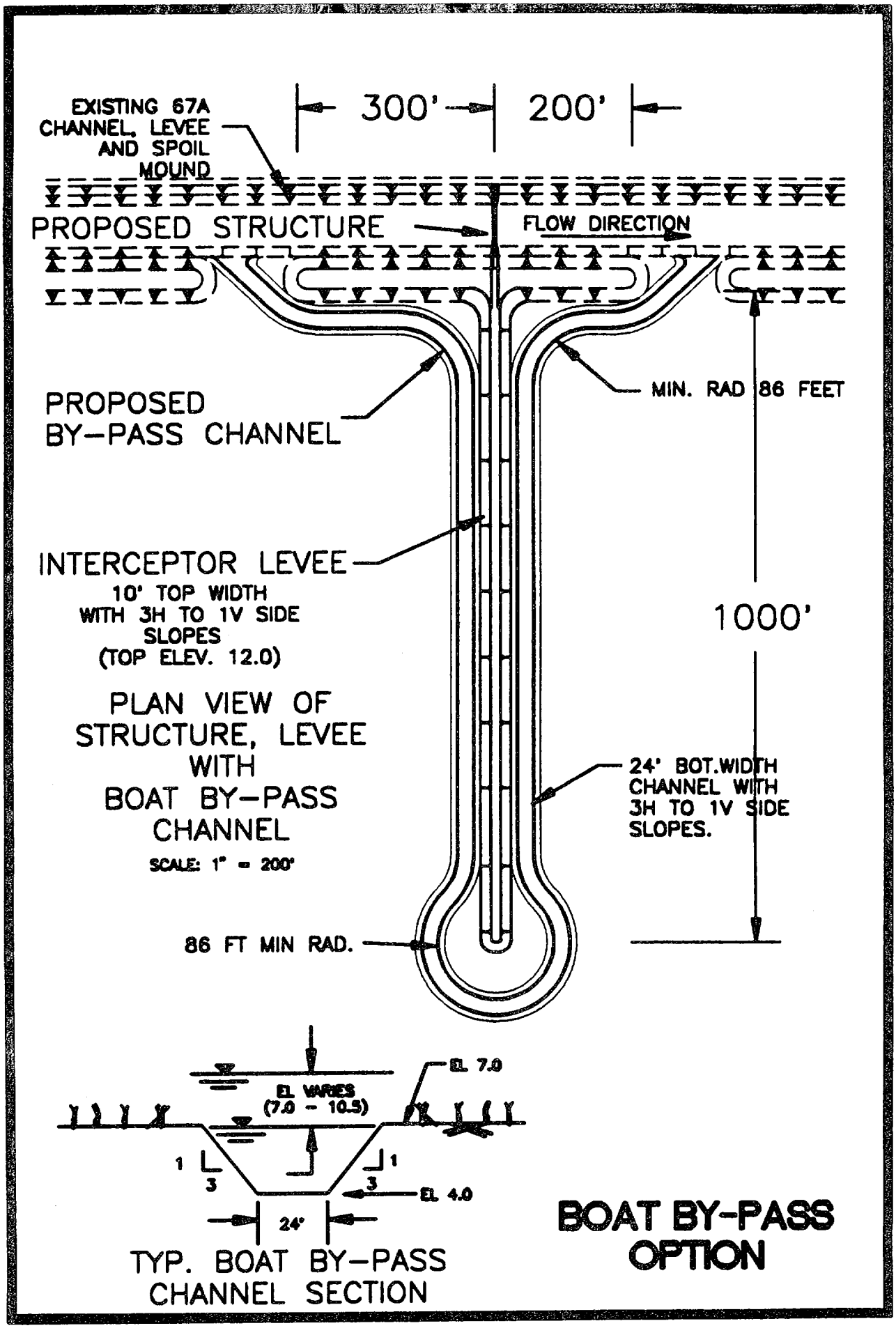

EXISTING 67A CHANNEL, LEVEE AND SPOIL MOUND
300'
200'
PROPOSED STRUCTURE
FLOW DIRECTION
PROPOSED BY-PASS CHANNEL
MIN. RAD 86 FEET
INTERCEPTOR LEVEE
10' TOP WIDTH WITH 3H TO 1V SIDE SLOPES (TOP ELEV. 12.0)
1000'
PLAN VIEW OF STRUCTURE, LEVEE WITH BOAT BY-PASS CHANNEL
SCALE: 1" = 200'
24' BOT.WIDTH CHANNEL WITH 3H TO 1V SIDE SLOPES.
86 FT MIN RAD.
EL 7.0
EL VARIES (7.0 - 10.5)
1
3
1
3
EL 4.0
24'
TYP. BOAT BY-PASS CHANNEL SECTION
BOAT BY-PASS OPTION

FIGURE 21

Modified Water Deliveries
Comparsion of Plans

	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8
Project's Objectives	Structures S-349 A,B,& C No boat access (Base Condition)	Structures S-349 A,B,& C with Boat Notch Option	Structures S-349 A,B,& C with Boat Lock Option	Structures S-349 A,B,& C with Boat Lift Option	Partial Plug Option	Six Spur Dike Option	Structures S-349 A,B,& C With Boat By-Pass Channel (Recommended Plan)	No Structures
Fishing Access	* No Access provided	Access provided	Access provided -Passage will be regulated by lock operator	* Access Provided - inconvenient to boaters	Access provided	Access provided	Access provided	Access provided
Hydrology Restoration Objectives	Fully allows for water distribution to WCA No 3A marshes	* Reduced water distribution to WCA No 3A marshes	Fully allows for water distribution to WCA No 3A marshes	Fully allows for water distribution to WCA No 3A marshes	* Does not allow for water distribution to WCA No 3A marshes	* Does not allow for water distribution to WCA No 3A marshes	Reduced water distribution to WCA No 3A marshes	* Does not allow for water distribution to WCA No 3A marshes
Water Management Objectives	Meets Water Supply Objectives	Meets Water Supply Objectives	Meets Water Supply Objectives	Meets Water Supply Objectives	* Does Not Meet Water Supply Objectives	Meets Water Supply Objectives	Meets Water Supply Objectives	Meets Water Supply Objectives
Navigation Safety	N / A Base Condition	* Potential Hazard-with small opening unsafe during high head differentials	Safe	* Potential Hazard to Boaters	Potential unsafe during low water levels	Safe	Safe	Safe
Environmental Impact	N / A Base condition	No Difference in loss of wetlands	Increased loss of wetlands	No Difference in loss of wetlands	No Difference in loss of wetlands	* Increase loss of wetlands	Increase loss of wetlands	Decrease loss of wetlands
Operation & Maintenance	N / A Base Condition	No Increase in O & M	* Extreme high increase in annual O & M	Increase in annual O & M	Reduce in annual O & M	Reduce in annual O & M	Increase in annual O & M	Decrease in annual O & M
Cost Impact	N / A Base Condition	Minimal increase in initial cost	* Very High increase in initial cost	High increase in initial cost	Reduction in initial cost	Increase in initial cost	Increase in initial cost	Reduction in initial cost cost

NOTE: Astericks (*) indicate primary reasons plans were not recommended.

FIGURE 22

Modified Water Deliveries to ENP

___ Critical ___ Hammock

02/21/91
16: 45: 48
Page 1

Figure 23

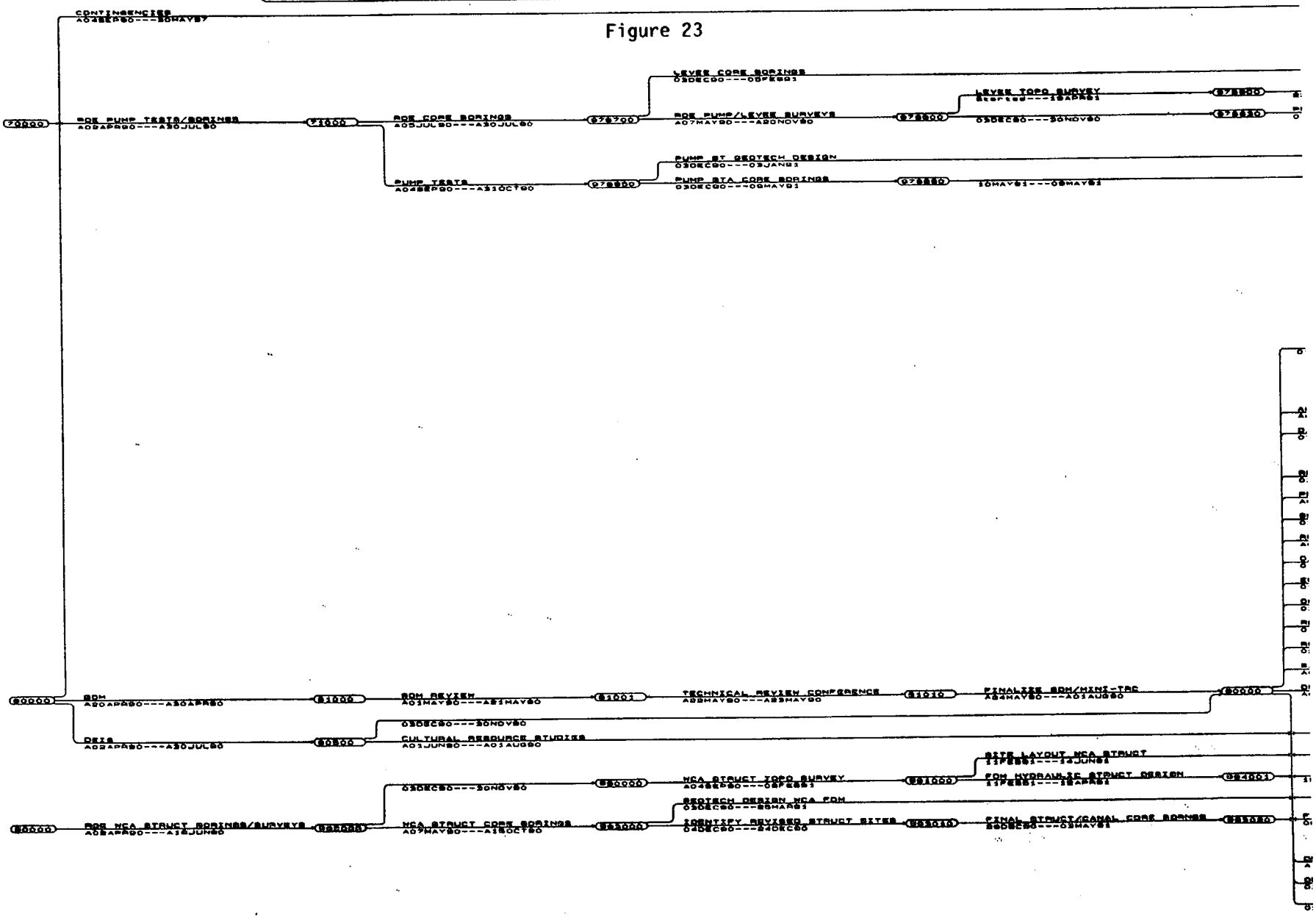


Figure 23 (Continued)

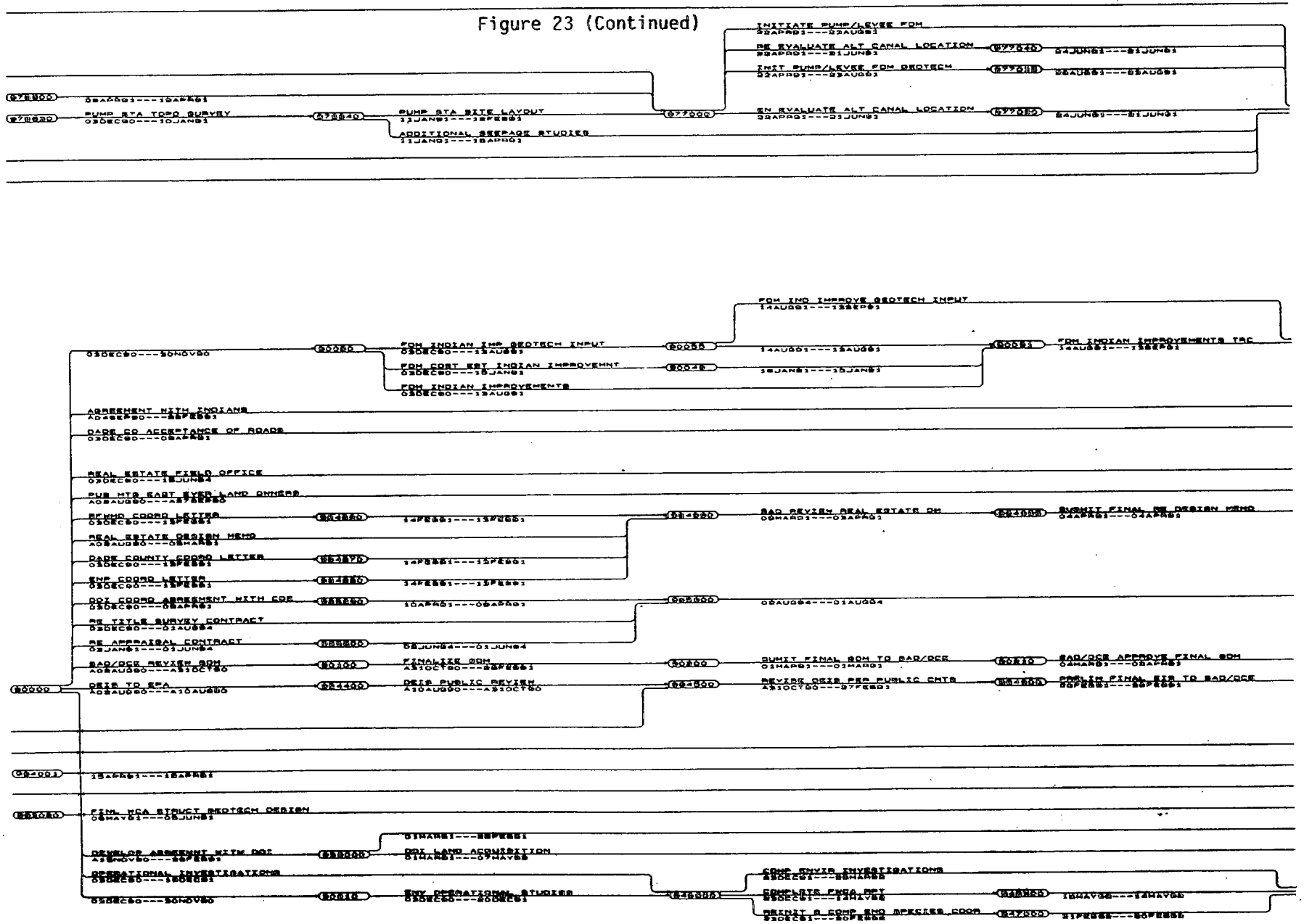
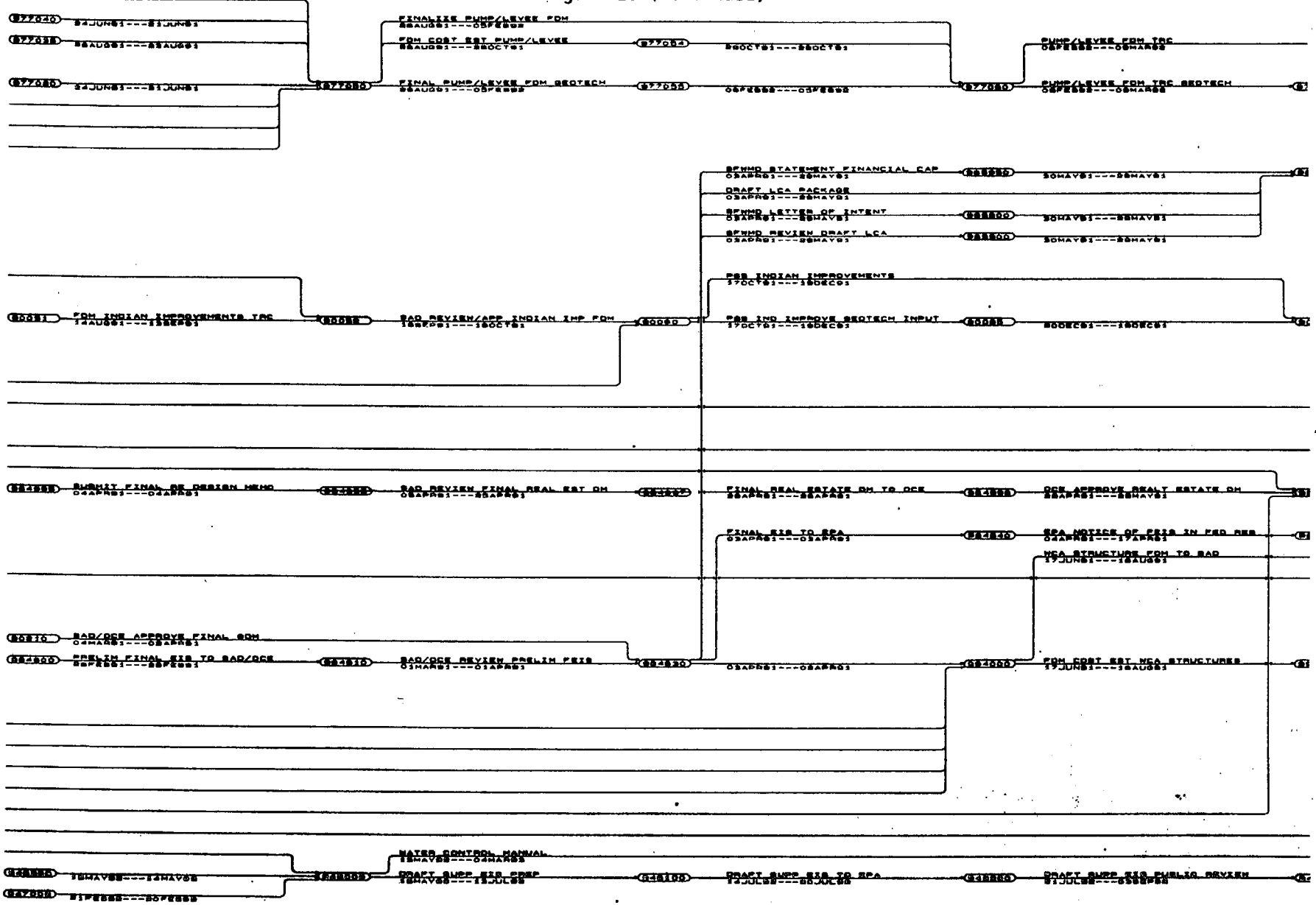


Figure 23 (Continued)



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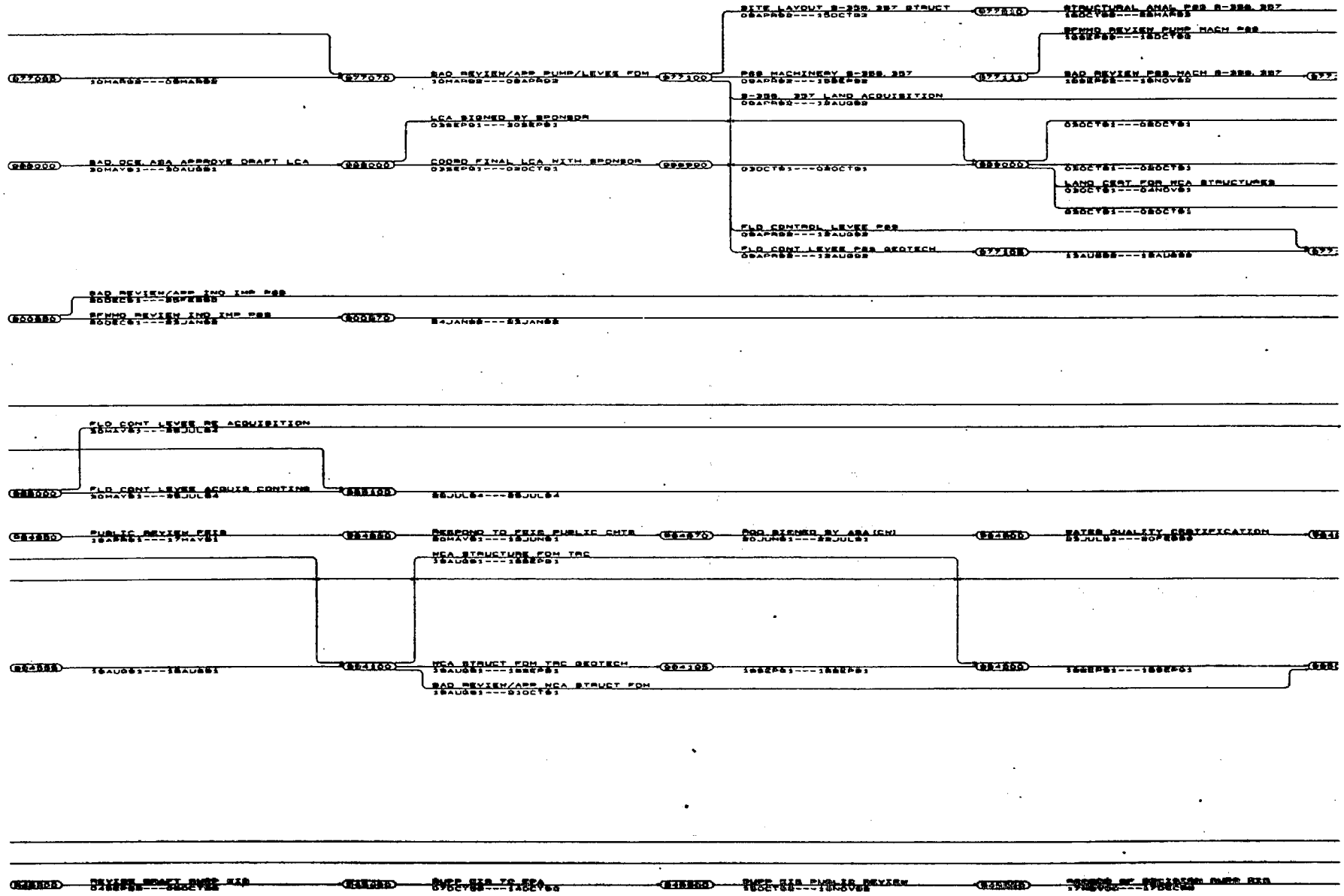


Modified Water Deliveries to ENP

___ Critical ___ Hammock

02/21/91
16: 45: 48
Page 5

Figure 23 (Continued)

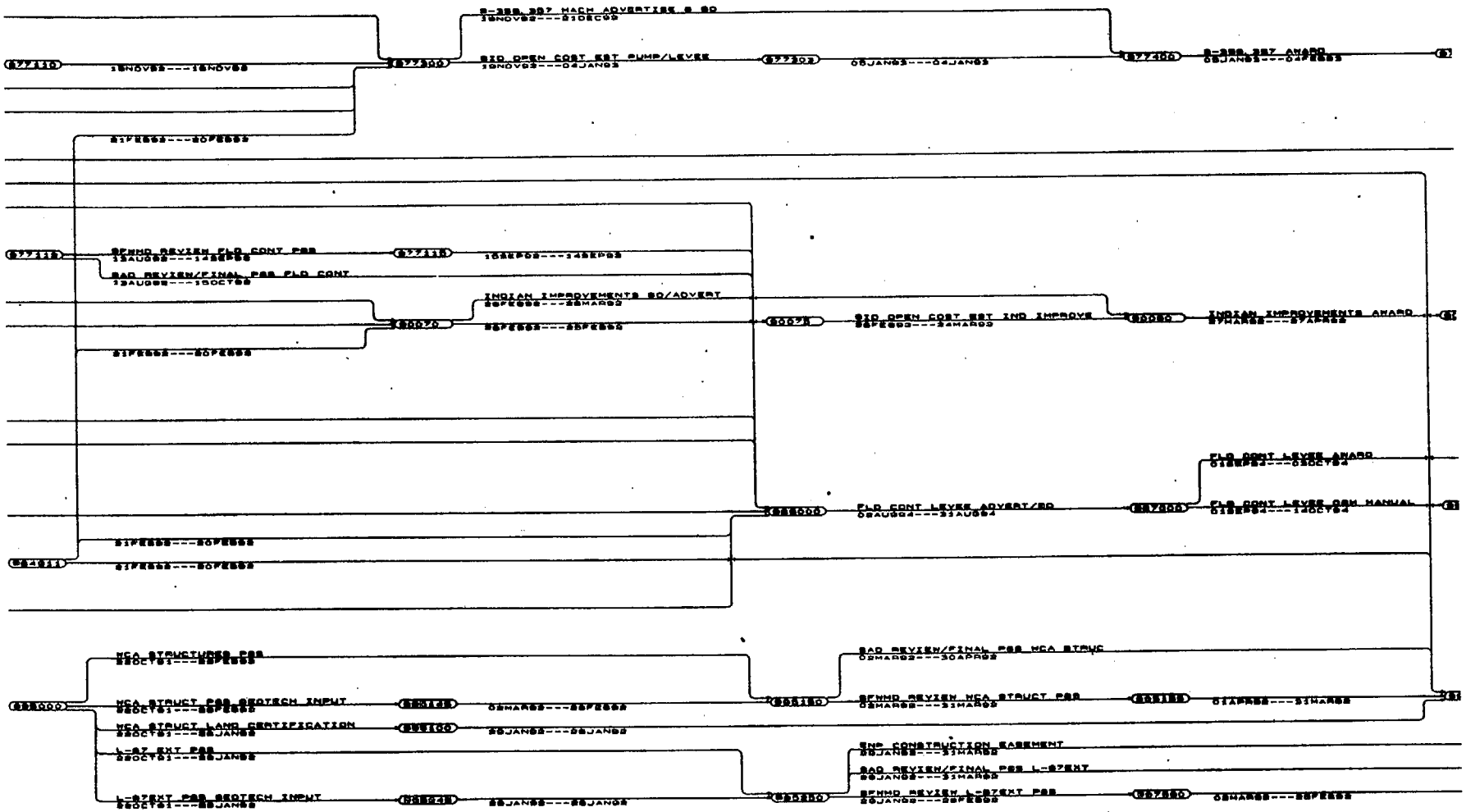


Figure 23 (Continued)

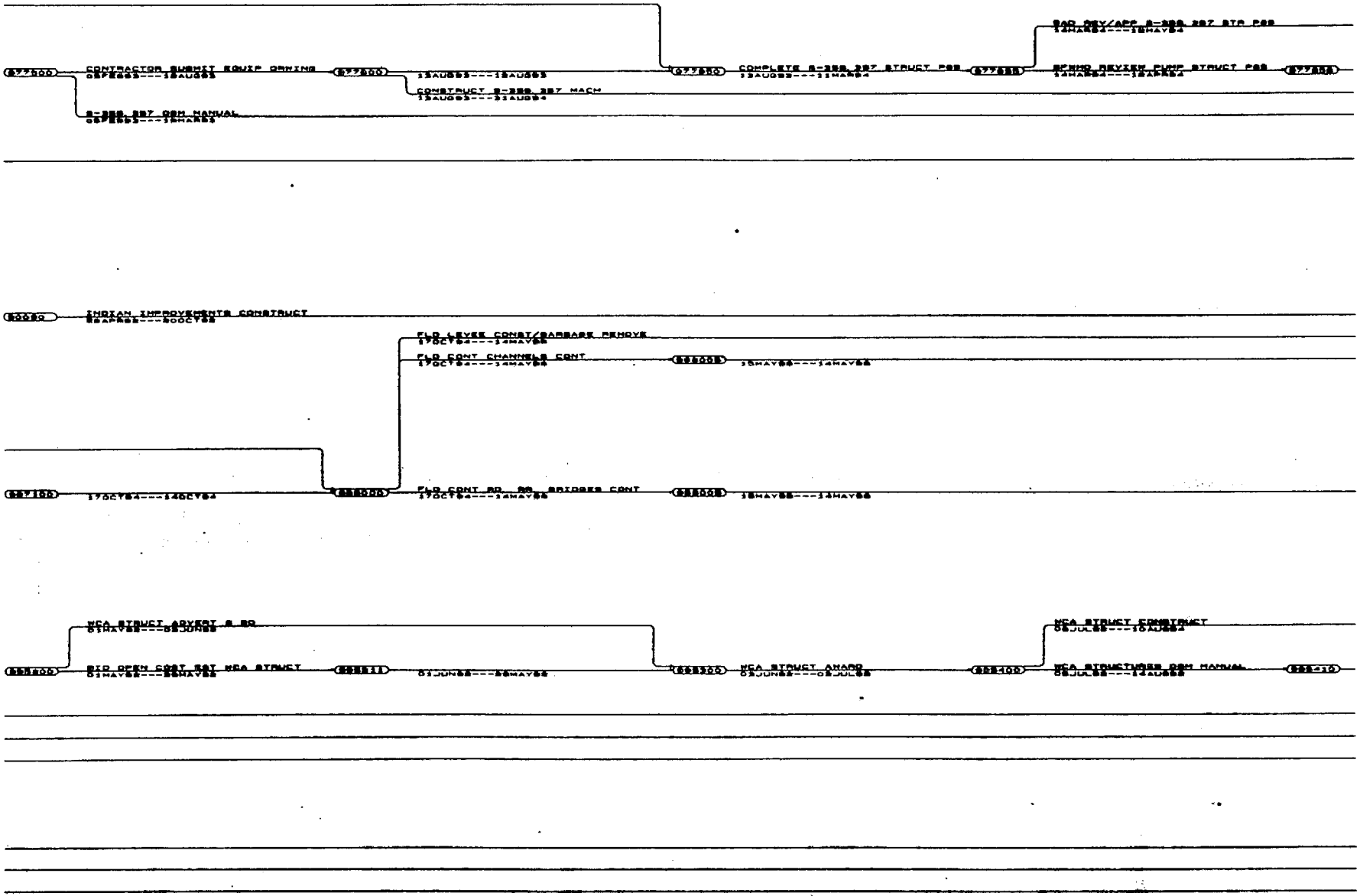
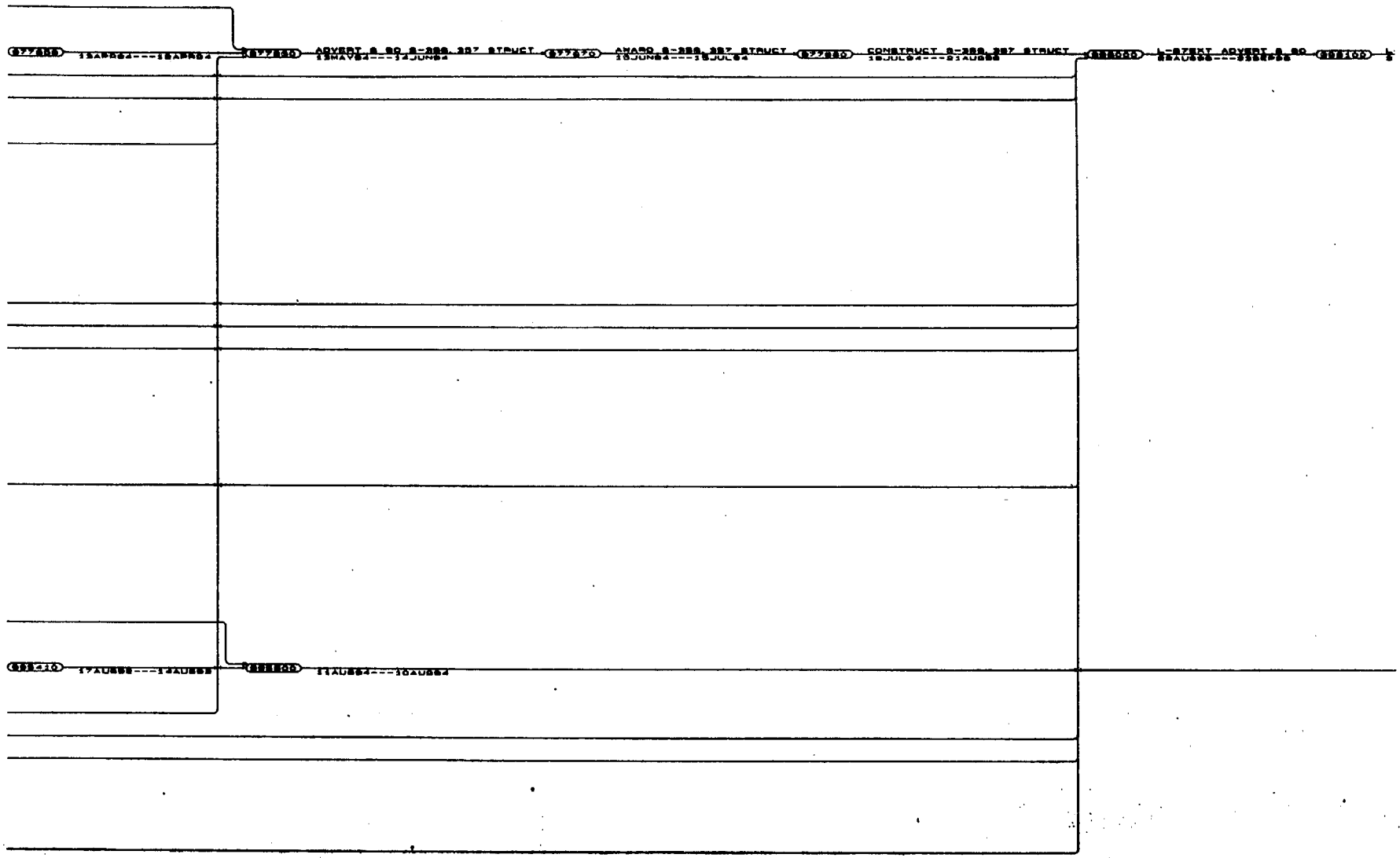


Figure 23 (Continued)



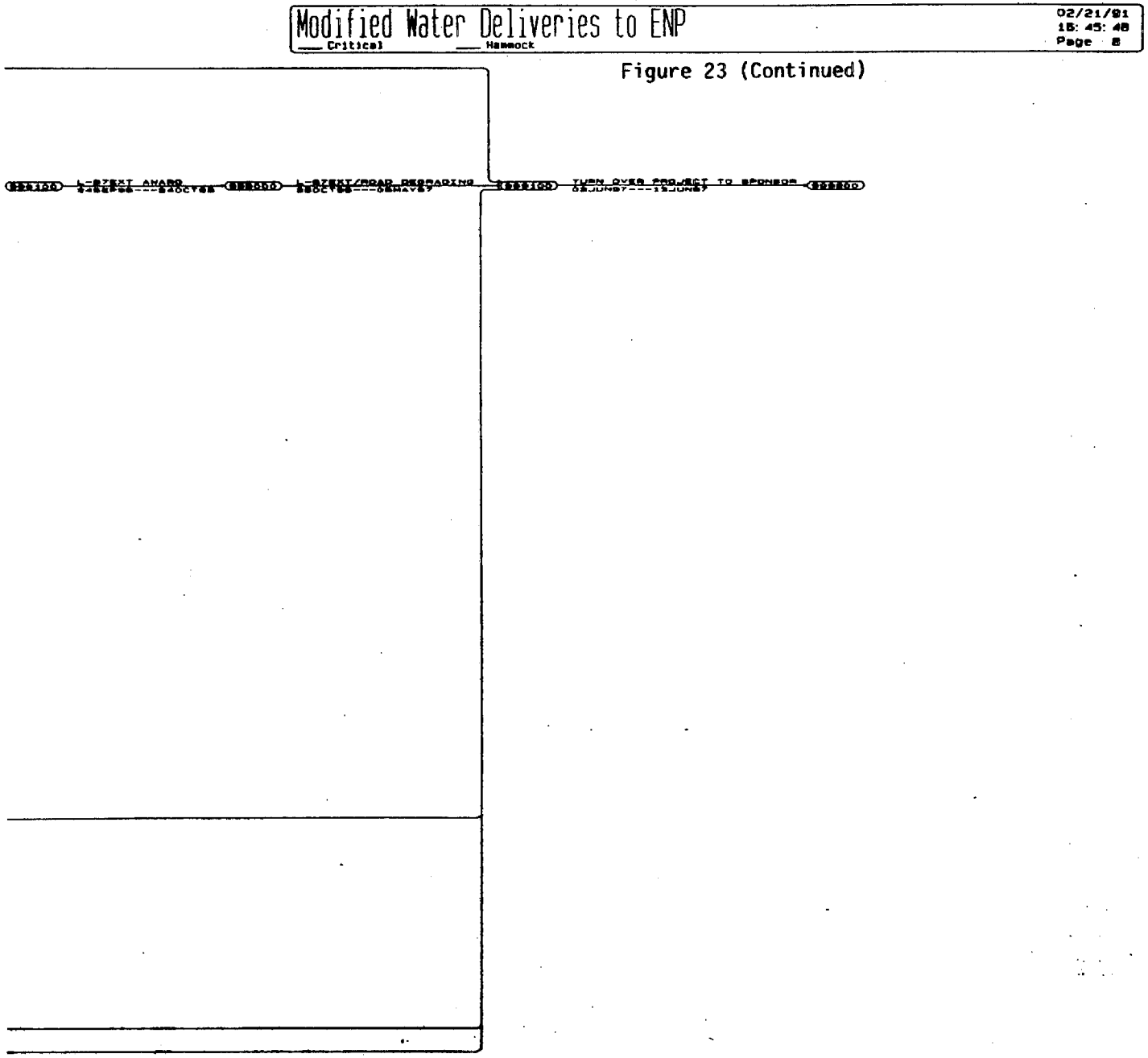


Figure 23 (Continued)

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

PART I

AGRICULTURAL AND CONSERVATION AREAS
SUPPLEMENT 54 - GENERAL DESIGN MEMORANDUM
MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

TABLES

Table 1

EVERGLADES ANNUAL TIMELINE

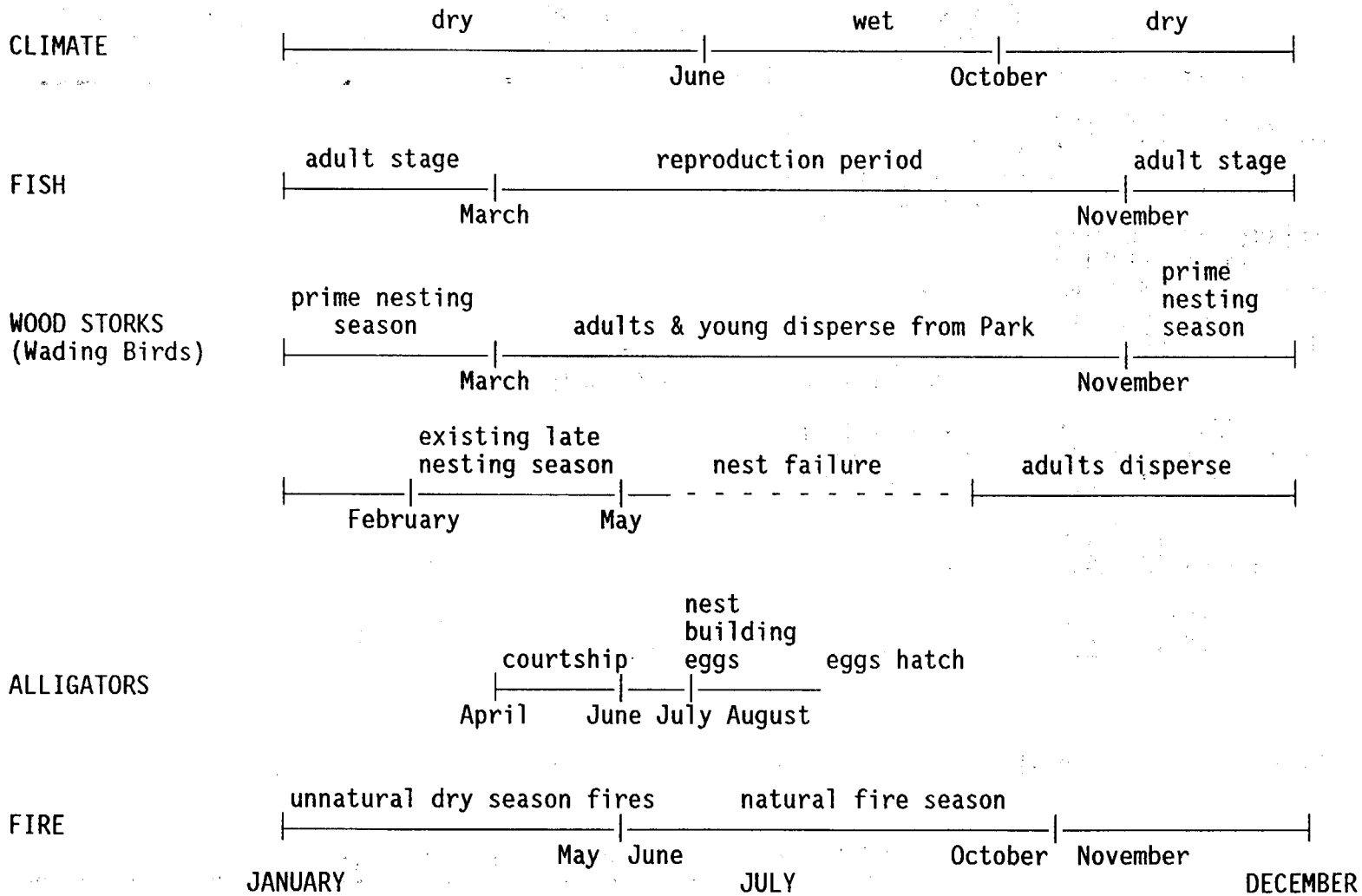


Table 2

TIMELINE OF EVERGLADES DEVELOPMENT

	1880	1920	1940	1960	1980	1990
CLIMATE & HYDROLOGIC EVENTS		(1926)Hurricane (1928)Hurricane	(1947)Hurricane	(1960)Hurricane Donna (1960-64)Extreme drought (1961-65)Virtually no water flowed through Park	(1981)Tropical Storm Dennis (1982-83)Extreme wet period (1982-present) Above normal water levels in Park	
LEGISLATION		(1934)ENP authorized by Congress	(1948)C&SF Project authorized	(1968)ENP-South Dade County Conveyance System authorized (1970)PL91-282 established minimum water delivery to ENP	(1984)ENP/East Everglades Resource Planning and Management Committee established by Governor of Florida (1989)ENP Protection and Expansion Act	
DEVELOPMENT	(1881)Hamilton Disston constructs canals to lower water levels in Kissimmee River Basin	(1927)Six major drainage canals constructed by Everglades Drainage District	(1940)USGS began taking flow measurements across Tamiami Trail (1947)ENP established	(1962)L-29 completed (final feature of WCA 3A) (1966)L-67 extension constructed	(1983-1986)Interim Action Plan (1986-present)LOOP (Lake Okeechobee Operating Permit) increased inflows to WCA 3A	

Table 2 (Continued)

TIMELINE OF EVERGLADES DEVELOPMENT

	1880	1920	1940	1960	1980	1990
DEVELOPMENT (cont.)			(1952)Eastern protection levee constructed (L-30)		(1983)Flow-Through System Water Deliveries Test (1984)30-Day Dry Season Test; 90-Day Dry Season Test (1985-87)Rain Driven Water Deliveries Test (1987-1992)Second Rain Driven Test	
OTHER REPORTS					(1985)General Plan for Implementation of an Improved Water Delivery System to ENP (1987)White Paper prepared	

Table 3

HISTORIC ECOLOGICAL CONDITIONS OF THE EVERGLADES

	Prior to 1930	1930 - 1960	1960 - 1990
WATER QUALITY	(Prior to 1934) Not affected by upstream alterations	(1950-1970) Hydrologic regime affected by major water management changes	
	Low nutrient status -- sawgrass dominance (low phosphorous requirements)		(1960-present) Increased concentrations of sodium chlorine, magnesium, color & iron resulting from connate seawater, breakdown of organic soils, peat fines & fertilizers
	Periphyton mats covered large area on a seasonal basis (food source for Everglades Crayfish)		(1980's) Reduced area for Periphyton
VEGETATION		(1930's) Sawgrass marshes; sloughs with aquatic plants; marsh prairies; tree island with bay forests; cypress forests; pine forests; hammock forests	(1980's) Sawgrass decreased; willow & cattails increased; woody species expand into wetlands; tree island size increased in central NESRS; mangroves established in marshes surrounding SRS headwaters; some marl prairies colonized by slash pine; tree islands size decreased in Eastern edge of NESRS; hardwoods in Southern end of WCA No. 3A have decreased in size

Table 3 (Continued)

HISTORIC ECOLOGICAL CONDITIONS OF THE EVERGLADES (Continued)

	Prior to 1930	1930 - 1960	1960 - 1990
ESTUARIES	(Prior to 1920) Abundant birds & fish	(After 1920) Decline in fish resources available to birds (After 1920) Decreased nesting for Osprey, Brown Pelican & White Ibis	
EXOTIC PLANTS	No problems	(After 1930) Water Hyacinth found in L-67 extension canal; Australian Pine established; Brazilian pepper colonized; spread of exotic species such as Melaleuca	
WADING BIRDS		Colony formation during November - December	(1960-1970) Colony formation during January - March (1970-1980's) Wood Stork population declines; Wading Bird population declines Current level for most species is approximately 10-20% of base that existed in 1934
ALLIGATORS	Abundant	Population declined by 10-20%	(1973) Listed on U.S. Endangered Species List; however, population began to increase
FIRES	Natural wet season occurrences	(After 1930) Dry season fires occurred which weakened native species & allowed spread of exotic species such as Melaleuca	

Table 4

PL 91–282 Minimum Monthly Water Deliveries (1,000 acre–feet)			
JAN	27.0	JUL	9.0
FEB	11.0	AUG	15.0
MAR	5.0	SEP	47.0
APR	2.0	OCT	81.0
MAY	2.0	NOV	71.0
JUN	6.0	DEC	39.0
TOTAL = 315.0			

Table 5

PL 91–282 Minimum Monthly Water Deliveries to Shark River Slough (1,000 acre–feet)			
JAN	22.0	JUL	7.4
FEB	9.0	AUG	12.2
MAR	4.0	SEP	39.0
APR	1.7	OCT	67.0
MAY	1.7	NOV	59.0
JUN	5.0	DEC	32.0
TOTAL = 260.0			

Table 6

PL 91–282 Minimum Monthly Water Deliveries to Taylor Slough (1,000 acre–feet)			
JAN	3.2	JUL	1.1
FEB	1.3	AUG	1.8
MAR	0.6	SEP	5.5
APR	0.2	OCT	9.5
MAY	0.2	NOV	8.3
JUN	0.7	DEC	4.6
TOTAL = 37.0			

Table 7

PL 91–282 Minimum Monthly Water Deliveries to Eastern Panhandle (1,000 acre–feet)			
JAN	1.8	JUL	0.5
FEB	0.7	AUG	1.0
MAR	0.4	SEP	2.5
APR	0.1	OCT	4.5
MAY	0.1	NOV	3.7
JUN	0.3	DEC	2.4
TOTAL = 18.0			

Table 8

AVERAGE ANNUAL DISCHARGE COMPARISON OF PROPOSED ALTERNATIVE PLANS

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
WCA NO. 3A MAJOR INFLOWS (1000 A-F)				
S-11	554	554	554	562
S-8	244	240	220	335
S-9	111	111	119	115
S-140	93	93	93	93
TOTAL	1002	998	986	1105
WCA NO. 3A MAJOR OUTFLOWS (1000 A-F)				
S-12	460	469	246	297
S-151	266	257	255	268
S-333	37	30	162	208
S-345	--	--	258	189
TOTAL	763	756	921	962
ENP-SOUTH DADE CONVEYANCE SYSTEM INFLOWS (1000 A-F)				
S-334	22	17	22	22
S-335	54	50	58	60
TOTAL	76	67	80	82
ENP WATER DELIVERIES (1000 A-F)				
S-12	460	469	246	297
S-333	---	---	162	208
S-355	---	---	121	104
S-356	---	150	72	72
TOTAL	460	619	601	681
DISTRIBUTION OF FLOWS (%)				
TO SRS VIA S-12	100	76	42	41
TO NESRS	0	24	58	59
TO NESRS FROM WCA NO. 3B	0	0	21	14

Table 8 (Continued)

AVERAGE ANNUAL DISCHARGE COMPARISON OF PROPOSED ALTERNATIVE PLANS

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
LAKE OKEECHOBEE WATER SUPPLY RELEASES (1,000 A-F)				
EEA	349	349	375	360
WCA No.1	0	0	0	0
WCA No.2	0	0	0	0
WCA No.3	90	87	76	132
TOTAL	439	436	452	493
EVERGLADES AGRICULTURAL AREA RUNOFF (1,000 A-F)				
WCA No.1	460	460	462	459
WCA No.2	255	255	264	262
WCA No.3	148	148	141	140
LAKE	131	131	138	136
TOTAL	995	995	1004	996
WATER CONSERVATION AREA No. 3B (1000 A-F)				
Inflows (S-345)	---	---	258	189
Outflows (S-355)	---	---	121	104
NET INFLOW	---	---	137	85

Table 8A

ANNUAL VOLUME CHANGE
(IN MILLIONS OF ACRE-FEET)

DRY YEAR 1971

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	0.146	0.147	0.169	0.168
2A	0.013	0.013	0.015	0.014
2B	0.004	0.004	0.001	0.003
3A	0.196	0.190	0.161	0.181
3B	-0.040	-0.040	-0.050	-0.039
L.O.	-0.644	-0.640	-0.610	-0.627
TOTAL	-0.325	-0.330	-0.310	-0.299

DRY YEAR 1973

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	0.074	0.074	0.084	0.084
2A	-0.002	-0.002	0.003	0.000
2B	0.004	0.004	0.005	0.004
3A	-0.140	0.140	0.093	0.077
3B	-0.001	-0.003	-0.014	0.015
L.O.	0.610	0.610	0.634	0.609
TOTAL	0.826	0.824	0.834	0.791

DRY YEAR 1981

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	-0.018	-0.020	-0.010	-0.013
2A	0.002	0.002	0.003	0.004
2B	-0.031	-0.030	-0.030	-0.032
3A	-0.075	0.060	-0.020	-0.106
3B	-0.016	-0.130	0.018	0.012
L.O.	-1.515	-1.500	-1.450	-1.476
TOTAL	-1.471	-1.480	-1.490	-1.608

Table 8A (Continued)

ANNUAL VOLUME CHANGE
(IN MILLIONS OF ACRE-FEET)

WET YEAR 1969

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	0.011	0.011	0.008	0.006
2A	-0.183	-0.018	-0.090	-0.180
2B	0.005	0.005	0.009	0.006
3A	0.350	0.350	0.471	0.543
3B	0.086	0.089	0.116	0.104
L.O.	0.979	0.979	0.984	0.947
TOTAL	1.247	1.252	1.502	1.426

WET YEAR 1974

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	0.023	0.024	0.014	0.018
2A	-0.005	-0.004	-0.010	-0.007
2B	-0.006	-0.010	-0.010	-0.006
3A	-0.072	-0.070	-0.050	-0.058
3B	-0.006	-0.010	-0.010	-0.009
L.O.	0.922	0.922	0.920	0.918
TOTAL	0.857	0.861	0.856	0.854

WET YEAR 1982

	BASE CONDITION	MODIFIED BASE	RAIN DRIVEN	MODIFIED RAIN-DRIVEN
#1	0.067	0.067	0.068	0.070
2A	0.001	0.000	0.004	0.000
2B	0.032	0.032	0.031	0.031
3A	0.202	0.206	0.200	0.238
3B	0.045	0.047	0.062	0.046
L.O.	2.459	2.456	2.457	2.461
TOTAL	2.806	2.807	2.823	2.845

TABLE 9

CHANGES RELATIVE TO BASE CONDITION IN MEDIAN STAGE (IN FEET)

RAIN–DRIVEN WATER DELIVERIES ALTERNATIVES

	BASIC	MODIFIED DELIVERIES	BASIC RAIN–DRIVEN	MODIFIED RAIN–DRIVEN
WCA No. 3				
3–2	10.8	0	0	0
3–3	9.7	0	.3	.1
3–4	9.4	0	0	.1
3–28	9.2	–.1	–.1	.1
3–29	7.2	0	0	0
EAST EVERGLADES				
NE–1	6.3	.5	.5	.5
NE–2	6.0	.8	.8	.8
G596	5.2	–.1	–.1	–.1
G1502	6.0	.2	.2	.3
ENP				
P–33	6.0	–.1	<–.1	<–.1
P–34	1.9	0	<–.1	0
NP–201	7.4	0	.2	–.2
NP–205	7.2	0	0	–.2
NP–206	5.8	0	0	0
TSRP	5.4	0	0	0
TSHO	4.8	0	.1	0

TABLE 10

CHANGES RELATIVE TO BASE CONDITION IN HYDROPERIOD (IN DAYS)

RAIN–DRIVEN WATER DELIVERIES ALTERNATIVES

	BASIC	MODIFIED DELIVERIES	BASIC RAIN–DRIVEN	MODIFIED RAIN–DRIVEN
WCA No. 3				
3–2	245	0	0	0
3–3	314	1	2	15
3–4	314	3	15	14
3–28	360	0	–35	0
3–29	303	5	0	14
EAST EVERGLADES				
NE–1	306	20	30	30
NE–2	292	47	55	55
G596	7	0	–7	–7
G1502	4	0	0	0
ENP				
P–33	343	–14	–7	–3
P–34	314	0	–20	–9
NP–201	317	0	3	3
NP–205	310	0	–36	–33
NP–206	270	–10	–15	0
TSRP	8	0	0	0
TSHO	45	0	0	0

TABLE 11

CHANGES RELATIVE TO BASE CONDITION IN PEAK STAGE (IN FEET)

RAIN–DRIVEN WATER DELIVERIES ALTERNATIVES

	BASIC	MODIFIED DELIVERIES	BASIC RAIN–DRIVEN	MODIFIED RAIN–DRIVEN
WCA No. 3				
3–2	12.4	.1	.5	1
3–3	11.9	0	1.1	.2
3–4	11.3	0	<–.1	.2
3–28	11.1	<–.1	–1.1	.1
3–29	9.5	0	.6	.3
EAST EVERGLADES				
NE–1	8.1	.5	1.0	1
NE–2	8.1	.5	1.4	1.5
G596	8.1	0	–2.1	–2.0
G1502	8.1	0	0	0
ENP				
P–33	8.0	.2	–.2	–.2
P–34	4.3	0	–.1	0
NP–201	9.4	.1	–.4	0
NP–205	8.5	0	–.2	0
NP–206	7.2	0	.1	.1
TSRP	6.8	0	0	0
TSHO	6.1	0	0	0

Table 12

EVALUATION OF ALTERNATIVE PLANS' EFFECTS
(RELATIVE TO BASE CONDITION)

	FT	RD	RRD	BRD	MRD	MMD
ENVIRONMENTAL						
Periphyton	Improved	Improved	Improved	Improved	Improved	Improved
Vegetation	Improved	Improved	Improved	Improved	Improved	Improved
Fish Forage Community	Improved	Improved	Improved	Improved	Improved	Improved
Wading Birds*						
Feeding Habitat Value		---	---	12% Loss	21% Loss	15% Gain
Nesting Success	---	---	---	21% Reduction	7% Reduction	1% Increase
Alligators*						
Habitat Value	---	---	---	1.1% Gain	1.6% Gain	1.4% Gain
Population Size	---	---	---	13% Increase	8% Increase	7% Increase
Fire	Less damaging	Less damaging	Less damaging	Less damaging	Less damaging	Less damaging
Exotic Plants	Retards spread	Retards spread	Retards spread	Retards spread	Retards spread	Retards spread
Endangered Species	Probable adverse effect on Snail Kite (not analyzed)	Probable adverse effect on Snail Kite (not analyzed)	Consultation pending	Adverse effect on Snail Kite**	No significant adverse effect	Beneficial to Wood Stork
Air Pollution	No effect	No effect	No effect	No effect	No effect	No effect

Table 12 (Continued)

EVALUATION OF ALTERNATIVE PLANS' EFFECTS
(RELATIVE TO BASE CONDITION)

	FT	RD	RRD	BRD	MRD	MMD
Noise Pollution	No effect	No effect	No effect	No effect	No effect	No effect
Water Pollution	No effect	No effect	No effect	No effect	No effect	No effect
Destruction of Manmade Resources	None	None	None	None	None	None
Destruction of Natural Resources (acres of wetlands)	***166	***166	0	***166	***166	***94
ECONOMIC						
Flood Control (Residential, Agricultural)	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive
Water Supply	---	Increased	---	Increased	Increased	Decreased
Recreation	Reduced	---	---	Reduced	Improved	No change
Employment Effects	No effect	No effect	No effect	No effect	No effect	No effect
Tax Value Effect	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive
Property Value Effect	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive

Table 12 (Continued)

EVALUATION OF ALTERNATIVE PLANS' EFFECTS
(RELATIVE TO BASE CONDITION)

	FT	RD	RRD	BRD	MRD	MMD
Injurious Displacement of People	No effect	No effect	No effect	No effect	No effect	No effect
Injurious Displacement of Businesses	No effect	No effect	No effect	No effect	No effect	No effect
Injurious Displacement of Farms	No effect	No effect	No effect	No effect	No effect	No effect
SOCIAL & CULTURAL						
Residences	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Indians (Airboat Access to WCA No. 3A)	Reduced	---	---	Reduced	Improved	No change
Cultural Resources	No effect	No effect	No effect	No effect	No effect	No effect
Destruction of Aesthetic Values	Insignificant	Insignificant	None	Insignificant	Insignificant	Insignificant
Destruction of Community Cohesion	No effect	No effect	No effect	No effect	No effect	No effect

Table 12 (Continued)

EVALUATION OF ALTERNATIVE PLANS' EFFECTS
(RELATIVE TO BASE CONDITION)

	FT	RD	RRD	BRD	MRD	MMD
Destruction of the Availability of Public Facilities & Services	No effect	No effect	No effect	No effect	No effect	No effect
Effect on Community Growth	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive
Effect on Regional Growth	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive	Minor positive

* Based on wildlife models of disputed validity.
** Pending resolution of Park's dispute
*** Functional improvement would be realized for 100,000 to 300,000 acres of Everglades wetlands through hydrological restoration.

NOTE: All alternatives include flood mitigation for East Everglades and monitoring of agricultural area.

KEY
FT - Flow-Through
RD - Rain Driven
RRD - Restricted Rain Driven
BRD - Basic Rain Driven
MRD - Modified Rain Driven
MMD - Modified Minimum Deliveries

Table 13

VIEWS OF OTHERS

	FT	RD	RRD	BRD	MRD	MMD
ENP	support (suggested by ENP)	support	support as test	support	*oppose	oppose
FWS	oppose	oppose	---	oppose (snail kite)	support	support
SFWMD	oppose	support (suggested by SFWMD)	support as test	support	*oppose	oppose
SOUTH DADE AGRICULTURAL INTERESTS	**	**	**	**	**	**
EAST EVERGLADES RESIDENTS	**	**	**	**	**	**
MICCOSUKEE INDIANS	---	---	---	---	---	---
EPA	oppose	support	---	support	---	---
FDER	oppose	support	---	support	---	---

Table 13 (Continued)

VIEWS of OTHERS (continued)

	FT	RD	RRD	BRD	MRD	MMD
DADE COUNTY	oppose	support	support as test	support	---	---
SETEC (SO. EVERGLADES TECH. COMMITTEE)	oppose	support	support as test	support	---	---
NMFS	---	---	---	support	support	suport
FGFWFC	---	---	---	support	support	suport

* Although the Modified Rain Driven Plan is not supported, agencies have agreed that if a preferred operating strategy cannot be developed before completion of construction, it will be implemented.

** The agricultural and residential interests have provided comments on only the flood mitigation component of the plan. The residential interests support the mitigation plan. The agricultural interests have not opposed the mitigation plan.

*** Supports if water quality is to be maintained in WCA No. 3B.

KEY

FT - Flow-Through
RD - Rain Driven
RRD - Restricted Rain Driven
BRD - Basic Rain Driven
MRD - Modified Rain Driven
MMD - Modified Minimum Deliveries

Table 14

PLANS OF OTHERS

	FT	RD	RRD	BRD	MRD	MMD
Everglades National Park: PL101-229 Land Acquisition	consistent	consistent	consistent	consistent	consistent	consistent
Everglades National Park: Seven-Point Plan						
South Florida Water Management District: Lake Okeechobee Operating Permit (LOOP)	consistent	consistent	consistent	consistent	consistent	consistent
South Florida Water Management District: Surface Water Improvement Management (SWIM) Plan	consistent	consistent	consistent	consistent	consistent	consistent
South Florida Water Management District: Interim C-111 Plan	* partially inconsistent	*	consistent	*	*	*
Dade County: West Dade Wellfield	**potentially inconsistent	**potentially inconsistent	**potentially inconsistent	**potentially inconsistent	**potentially inconsistent	**potentially inconsistent

* Interim C-111 Plan consists of 2 componenets: placing culverts at S-197 which is consistent with alternative plans and addition of a culvert in the L-31N borrow canal, upstream of S-331 which is inconsistent. SFWMD plans to remove the L-31N culvert when the plan is implemented.

** The West Dade Wellfield could adversely impact the project. However, the ENP Protection and Expansion Act requires that adverse impacts must be avoided.

KEY

FT - Flow-Through
RD - Rain Driven
RRD - Restricted Rain Driven
BRD - Basic Rain Driven
MRD - Modified Rain Driven
MMD - Modified Minimum Deliveries

Table 15

RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

	FT	RD	RRD	BRD	MRD	MMD
Federal Statutes:						
Archeological and Historical Preservation Act, as amended.	Full	Full	Full	Full	Full	Full
Clean Air Act, as amended.	N/A	N/A	N/A	N/A	N/A	N/A
Clean Water Act, as amended, (Federal Water Pollution Control Act).	Full	Full	Full	Full	Full	Full
Coastal Zone Management Act, as amended.	N/A	N/A	N/A	N/A	N/A	N/A
Endangered Species Act, as amended.	Incomplete	Incomplete	Incomplete	Non	Full	Full
Estuary Protection Act.	N/A	N/A	N/A	N/A	N/A	N/A
Federal Water Project Recreation Act, as amended.	Full	Full	Full	Full	Full	Full
Fish and Wildlife Coordination Act, as amended.	Incomplete	Incomplete	Incomplete	Full	Full	Full
Land and Water Conservation Fund Act, as amended.	N/A	N/A	N/A	N/A	N/A	N/A
Marine Protection, Research, and Sanctuaries Act.	N/A	N/A	N/A	N/A	N/A	N/A
National Historic Preservation Act, as amended.	Full	Full	Full	Full	Full	Full
National Environmental Policy Act, as amended.	Incomplete	Incomplete	Incomplete	Full	Full	Full
River and Harbors Act.	N/A	N/A	N/A	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act.	N/A	N/A	N/A	N/A	N/A	N/A
Wild and Scenic Rivers Act, as amended.	N/A	N/A	N/A	N/A	N/A	N/A
Executive Orders, Memoranda, etc.:						
Floodplain Management (E.O. 11988)	N/A	N/A	N/A	N/A	N/A	N/A
Protection of Wetlands (E.O. 11990)	Full	Full	Full	Full	Full	Full
Environmental Effects Abroad of Major Federal Actions (E.O. 12114)	N/A	N/A	N/A	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 30 Aug 76)	Full	Full	Full	Full	Full	Full

NOTES: The compliance categories used in this table were assigned based on the following definitions:

a. Full compliance -- All requirements of the statute, E.O., or other policy and related regulations have been met.
b. Partial compliance -- Some requirements of the statute, E.O., or other policy and related regulations remain to be met.
c. Noncompliance -- None of the requirements of the statute, E.O., or other policy and related regulations have been met.
d. Not Applicable -- N/A statute, E.O., or other policy not applicable.
e. Incomplete -- Preliminary plans, analysis not needed.

Table 16

EVALUATION OF FLOOD MITIGATION MEASURES

PLAN	PROTECTED AREA	LEVEL OF PROTECTION	FIRST COST (millions)	ANNUAL* COST (millions)	O&M COST (thousands)	MAXIMUM REDUCTION IN DAMAGES (thousands)	ENVIRONMENTAL IMPACTS
Non-Structural	RES + SOME AG	MIT	$43.5-78	$3.9-7	**	$65.5	NONE
A	RES + AG	MIT	APPROX. $43.5	$3.9	$48.4	$1,471.6	WETLAND LOSS UNNATURAL HYDROLOGY
B	RES + AG	MIT	APPROX. $35	$3.2	$68.3	$1,650.3	WETLAND LOSS UNNATURAL HYDROLOGY
C	RES + AG	MIT + FC	APPROX. $44.5	$4	$47.7	$2,328.1	WETLAND LOSS UNNATURAL HYDROLOGY
D	RES + AG	MIT	APPROX. $39	$3.5	$39.7		UNNATURAL HYDROLOGY
E	RES + AG	MIT	$41	$3.7	$37.2	$1,631.6	NONE
F	RES + AG	MIT	$28	$2.5	$57.4	$1,631.6	NONE
G	RES + AG	MIT	$26	$2.3	$50.1	$1,631.6	NONE

* 50 Year project life, 8-7/8% project evaluation interest rate (does not include interest during construction).
** No physical maintenance, only periodic inspections for encroachment.

KEY

AG - AGRICULTURAL
FC - FLOOD CONTROL
RES - RESIDENTIAL
MIT - MITIGATION

Table 17

PROJECT COST SUMMARY - MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

FEBRUARY 1991 PRICE LEVEL

ACCOUNT CODE	ITEM	ESTIMATED COST	CONTINGENCY	TOTAL COST	SUBTOTAL COST
STRUCTURE 345A					
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000	
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	175,000	44,000	219,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000	4,013,000
STRUCTURE 345B					
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000	
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	175,000	44,000	219,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000	4,013,000
STRUCTURE 345C					
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000	
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	175,000	44,000	219,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000	4,013,000
STRUCTURE 349A					
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000	
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	792,000	168,000	960,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000	1,409,000
STRUCTURE 349B					
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000	
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	792,000	168,000	960,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000	1,409,000
STRUCTURE 349C					
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000	
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	792,000	168,000	960,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000	1,409,000

Table 17 (Continued)

PROJECT COST SUMMARY - MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

FEBRUARY 1991 PRICE LEVEL

ACCOUNT CODE	ITEM	ESTIMATED COST	CONTINGENCY	TOTAL COST	SUBTOTAL COST
STRUCTURE 355A					
09.-.-.-	CHANNELS AND CANALS	306,000	77,000	383,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	1,068,000	267,000	1,335,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	117,000	29,000	146,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	96,000	24,000	120,000	1,984,000
STRUCTURE 355B					
09.-.-.-	CHANNELS AND CANALS	306,000	77,000	383,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	1,068,000	267,000	1,335,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	117,000	29,000	146,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	96,000	24,000	120,000	1,984,000
NEW SPILLWAY STRUCTURE S-334					
11.-.-.-	LEVEES AND FLOODWALLS	303,000	74,000	377,000	
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCT.	1,106,000	273,000	1,379,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	120,000	29,000	149,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	99,000	24,000	123,000	2,028,000
U.S. 41 RAISING AND RAMPING					
08.-.-.-	ROADS, RAILROADS AND BRIDGES				
08.2.-.-	ROADS	2,014,000	478,000	2,492,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	171,000	41,000	212,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	141,000	33,000	174,000	2,878,000
PUMPING STATION S-356					
09.-.-.-	CHANNELS AND CANALS	745,000	186,000	931,000	
11.-.-.-	LEVEES AND FLOODWALLS	412,000	103,000	515,000	
13.-.-.-	PUMPING PLANT	9,320,000	5,144,000	14,464,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	891,000	462,000	1,353,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	733,000	380,000	1,113,000	18,376,000
DEGRADING OF LEVEE L-67 EXTENSION					
11.-.-.-	LEVEES AND FLOODWALLS	2,585,000	525,000	3,110,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	220,000	45,000	265,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	181,000	37,000	218,000	3,593,000

Table 17 (Continued)

PROJECT COST SUMMARY - MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

FEBRUARY 1991 PRICE LEVEL

ACCOUNT CODE	ITEM	ESTIMATED COST	CONTINGENCY	TOTAL COST	SUBTOTAL COST
FLOOD PROTECTION TO RESIDENTIAL AREA					
02.-.-.-	RELOCATIONS	1,715,000	429,000	2,144,000	
08.-.-.-	ROADS, RAILROADS AND BRIDGES				
08.2.-.-	ROADS	700,000	143,000	843,000	
09.-.-.-	CHANNELS AND CANALS	6,972,000	1,743,000	8,715,000	
11.-.-.-	LEVEES AND FLOODWALLS	3,676,000	919,000	4,595,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	1,110,000	275,000	1,385,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	914,000	226,000	1,140,000	18,822,000
MICCOSUKEE INDIAN - TIGER TAIL CAMP MITIGATION					
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES	301,000	67,000	368,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	35,000	8,000	43,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	14,000	3,000	17,000	428,000
MICCOSUKEE INDIAN - OSCEOLA CAMP MITIGATION					
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES	201,000	49,000	250,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	34,000	8,000	42,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	14,000	3,000	17,000	309,000
PUMPING STATION S-357					
13.-.-.-	PUMPING PLANT	4,107,000	874,000	4,981,000	
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	349,000	74,000	423,000	
31.-.-.-	CONSTRUCTION MANAGEMENT	287,000	61,000	348,000	5,752,000
SUBTOTAL PROJECT COST		55,739,000	16,681,000	72,420,000	
REAL ESTATE COSTS					
01.-.-.-	LANDS AND DAMAGES (FOR RESIDENTIAL AREA)	5,751,000	1,438,000	7,189,000	
30.D.-.-	ENVIRONMENTAL & REGULATORY ACTIVITIES				
	Endangered Species Monitoring (Snail Kite)	400,000	0	400,000	
	Agriculture Area Monitoring Wells	40,000	10,000	50,000	
	Hydrological Monitoring	20,000	5,000	25,000	
TOTAL PROJECT COST		$61,950,000	$18,134,000	$80,084,000	

Table 17A

SUMMARY OF FEDERAL AND NON-FEDERAL COSTS
(Date of Estimates: February 1991)

Cost Account No.	Item	Amount	Total
	CONSTRUCTION COSTS		
09, 11, 15	Structure 345A	3,902,000	
09, 11, 15	Structure 345B	3,902,000	
09, 11, 15	Structure 345C	3,902,000	
09, 11, 15	Structure 349A	1,220,000	
09, 11, 15	Structure 349B	1,220,000	
09, 11, 15	Structure 349C	1,220,000	
09, 15	Structure 355A	1,718,000	
09, 15	Structure 355B	1,718,000	
11, 15	New Spillway Structure S-334	1,756,000	
08	U.S. 41 Raising and Ramping	2,492,000	
09, 11, 13	Pumping Station S-356	15,910,000	
11	Degrading of L-67 Extension	3,110,000	
02, 08, 09, 11	Residential Area Flood Prot.	16,297,000	
13	Pumping Station S-357	4,981,000	
19	Tigertail Camp Mitigation	411,000	
19	Osceola Camp Mitigation	250,000	
	Total Contract Price	64,009,000	
31	Supervision and Administration	4,464,000	
	Construction Costs		$ 68,473,000
	FEDERAL COSTS		
	Initial		
	100% of Construction Costs	68,473,000	
30	Engineering & Design	5,469,000	
30.D	Environmental Monitoring	475,000	
01	Lands and Damages		
	Lands	3,185,000	
	Improvements	66,000	
	Easements	146,000	
	Severance	20,000	
	Minerals	0	
	P.L. 91-646	137,000	
	Acquisitions	3,359,000	
	Initial Federal Costs		$ 81,330,000

Table 17A (Continued)

SUMMARY OF FEDERAL AND NON-FEDERAL COSTS
(Date of Estimates: February 1991)

Cost Account No.	Item	Amount		Total
	NON-FEDERAL COSTS			
	Annual	2 1/2%	8 3/4%	
	Operating and Maintenance (25%)			
15	Structure 345(A,B,C)	6,100	6,100	
15	Structure 349(A,B,C)	1,400	1,400	
15	Structure 334	1,600	1,600	
15	Structure 355(A,B)	3,800	3,800	
13	Residential Area Flood Prot.	9,300	9,300	
13	Pumping Station S-356	23,100	23,100	
13	Pumping Station S-357	14,800	14,800	
	Equipment Replacement Costs (25%)			
15	Structure 345(A,B,C)	4,100	2,400	
15	Structure 349(A,B,C)	10,700	5,700	
15	Structure 334	1,300	1,000	
15	Structure 355(A,B)	9,500	5,300	
13	Pumping Station S-356	16,100	8,400	
13	Pumping Station S-357	5,400	3,100	
	Annual Non-Federal Costs	$ 107,200	$ 86,000	

Grand Total - Initial Federal and Non-Federal Costs	$ 81,330,000
Grand Total - Annual Federal and Non-Federal Costs (2 1/2%)	428,600
(8 3/4%)	343,000

Table 17A (Continued)

SUMMARY OF FEDERAL AND NON-FEDERAL COSTS
(Date of Estimates: February 1991)

Cost Account No.	Item	Amount		Total
	FEDERAL COSTS			
	Annual	2 1/2%	8 3/4%	
	Operating and Maintenance (75%)			
15	Structure 345(A,B,C)	18,400	18,400	
15	Structure 349(A,B,C)	4,300	4,300	
15	Structure 334	4,700	4,700	
15	Structure 355(A,B)	11,500	11,500	
13	Residential Area Flood Prot.	27,800	27,800	
13	Pumping Station S-356	69,400	69,400	
13	Pumping Station S-357	44,300	44,300	
	Equipment Replacement Costs (75%)			
15	Structure 345(A,B,C)	12,200	7,100	
15	Structure 349(A,B,C)	32,000	17,400	
15	Structure 334	3,900	2,300	
15	Structure 355(A,B)	28,600	15,700	
13	Pumping Station S-356	48,200	25,000	
13	Pumping Station S-357	16,100	9,100	
	Annual Federal Costs	321,400	257,000	
	NON-FEDERAL COSTS			
	Initial			
	0% of Construction Costs	0		
01	Lands and Damages	0		
	Initial Non-Federal Costs			$ 0

Table 18

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345A

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	175,000	44,000	219,000
	TOTAL CONSTRUCTION COST	2,779,000	695,000	3,474,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000
	TOTAL COSTS (STRUCTURE 345A)	$3,210,000	$803,000	$4,013,000

Table 19

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345B

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	175,000	44,000	219,000
	TOTAL CONSTRUCTION COST	2,779,000	695,000	3,474,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000
	TOTAL COSTS (STRUCTURE 345B)	$3,210,000	$803,000	$4,013,000

Table 20

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345C

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	746,000	187,000	933,000
11.-.-.-	LEVEES AND FLOODWALLS	1,858,000	464,000	2,322,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	175,000	44,000	219,000
	TOTAL CONSTRUCTION COST	2,779,000	695,000	3,474,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	236,000	59,000	295,000
31.-.-.-	CONSTRUCTION MANAGEMENT	195,000	49,000	244,000
	TOTAL COSTS (STRUCTURE 345C)	$3,210,000	$803,000	$4,013,000

Table 21

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345A
(Costs are identical for Structures 345B & 345C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 09.0.Z.-)	TOTAL PROJECT COST
09.-.-.-	CHANNELS AND CANALS Structure 345A							
09.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	42,000	25	10,500	52,500
09.0.3.-	CANALS:							
09.0.3.B	Site Work - Discharge Canal							
	Excavation, Common	61,400	CY	4.55	279,370	25	69,843	349,213
	Drilling and Blasting	29,600	CY	8.50	251,600	25	62,900	314,500
	Excavation (Rock)	29,600	CY	5.85	173,160	25	43,290	216,450
	Subtotal, Construction Costs:				$746,000			
09.0.Z.-	Contingencies @ average of 25.1%						$187,000	
09.-.-.-	Channels And Canals Total:							$933,000

Table 21 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345A
(Costs are identical for Structures 345B & 345C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.-.-.-	LEVEES AND FLOODWALLS Structure 345A							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	105,000	25	26,250	131,250
11.0.1.-	LEVEES							
11.0.1.B	Site Work - Tie-back Levees							
	Clearing and Grubbing	15	AC	1,000	15,000	25	3,750	18,750
	Grassing	15	AC	1,500	22,500	25	5,625	28,125
	Embankment Fill, Commercial Borrow	153,400	CY	10.70	1,641,380	25	410,345	2,051,725
	Embankment Fill, Canal Excavation	29,600	CY	2.50	74,000	25	18,500	92,500
	Subtotal, Construction Costs:				$1,858,000			
11.0.Z.-	Contingencies @ average of 25.0%						$464,000	
11.-.-.-	Levees And Floodwalls Total:							$2,322,000

Table 21 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 345A
(Costs are identical for Structures 345B & 345C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES Structure 345A							
15.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	10,000	25	2,500	12,500
15.0.D.- 15.0.D.B	Earthwork for Structures: Sitework							
	Excavation, Common	3,300	CY	4.55	15,015	25	3,754	18,769
	Drilling and Blasting	700	CY	8.50	5,950	25	1,488	7,438
	Excavation and Hauling, Rock	700	CY	6.30	4,410	25	1,103	5,513
	Gravel Bedding	200	CY	20.00	4,000	25	1,000	5,000
	Fill & Backfill	1,900	CY	5.00	9,500	25	2,375	11,875
	Riprap Stone (18")	270	CY	40.00	10,800	25	2,700	13,500
	Bedding Stone (12")	180	CY	35.00	6,300	25	1,575	7,875
	Temporary Levee, (Construct & Remove)	1,300	CY	6.00	7,800	25	1,950	9,750
	Sand-Cement Riprap	1,300	CF	7.00	9,100	25	2,275	11,375
	72 " Diameter C.M.P	255	LF	135.00	34,425	25	8,606	43,031
	Guardrail	100	LF	20.60	2,060	25	515	2,575
15.0.E.- 15.0.E.B	Foundation Work: Sitework							
	Timber Piling	250	LF	13.00	3,250	25	813	4,063
	Timber Walkway & Platform	220	SF	25.00	5,500	25	1,375	6,875
	Staff Gages	1	JOB	LS	2,000	25	500	2,500
15.0.4.- 15.0.4.E	Gates and Associated Equipment Metals							
	72" Diam. Slide Gates w/Manual Hoist	3	EA	15,000	45,000	25	11,250	56,250
	Subtotal, Construction Costs:				$175,000			
15.0.Z.-	Contingencies @ average of 25.1%						$44,000	
15.-.-.-	Floodway Control And Diversion Structures Total:							$219,000

Table 22

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349A

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	792,000	168,000	960,000
	TOTAL CONSTRUCTION COST	1,000,000	220,000	1,220,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000
	TOTAL COSTS (STRUCTURE 349A)	$1,155,000	$254,000	$1,409,000

Table 23

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349B

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	792,000	168,000	960,000
	TOTAL CONSTRUCTION COST	1,000,000	220,000	1,220,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000
	TOTAL COSTS (STRUCTURE 349B)	$1,155,000	$254,000	$1,409,000

Table 24

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349C

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	66,000	17,000	83,000
11.-.-.-	LEVEES AND FLOODWALLS	142,000	35,000	177,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	792,000	168,000	960,000
	TOTAL CONSTRUCTION COST	1,000,000	220,000	1,220,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	85,000	19,000	104,000
31.-.-.-	CONSTRUCTION MANAGEMENT	70,000	15,000	85,000
	TOTAL COSTS (STRUCTURE 349C)	$1,155,000	$254,000	$1,409,000

Table 25

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349A
(Costs are identical for Structures 349B & 349C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 09.0.Z.-)	TOTAL PROJECT COST
09.-.-.-	CHANNELS AND CANALS Structure 349A							
09.0.3.-	CANALS Site Work - Bypass Channel							
	Excavation, (Peat)	6,000	CY	3.00	18,000	25	4,500	22,500
	Excavation, Hauling, Rock	4,000	CY	12.00	48,000	25	12,000	60,000
	Subtotal, Construction Costs:				$66,000			
09.0.Z.-	Contingencies @ average of 25.8%						$17,000	
09.-.-.-	Channels And Canals Total:							$83,000

Table 25 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349A
(Costs are identical for Structures 349B & 349C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.-.-.-	LEVEES AND FLOODWALLS Structure 349A							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	8,000	20	1,600	9,600
11.0.1.-	LEVEES							
11.0.1.B	Site Work - Interceptor Levee							
	Clearing & Grubbing	3	ACRE	1,000	3,000	20	600	3,600
	Embankment Fill, Interceptor Levee	4,000	CY	6.70	26,800	25	6,700	33,500
	Embankment Fill, Commercial Borrow	9,500	CY	10.70	101,650	25	25,413	127,063
	Grassing, Interceptor Levee	1.5	ACRE	1,500	2,250	20	450	2,700
	Subtotal, Construction Costs:				$142,000			
11.0.Z.-	Contingencies @ average of 24.6%						$35,000	
11.-.-.-	Levees And Floodwalls Total:							$177,000

Table 25 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349A
(Costs are identical for Structures 349B & 349C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES							
	Structure 349A							
15.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	45,000	20	9,000	54,000
15.0.B.-	Care and Diversion of Water:							
15.0.B.B	Site Work							
	Dewatering	1	JOB	LS	165,000	20	33,000	198,000
15.0.D.-	Earthwork for Structures:							
15.0.D.B	Sitework							
	Excavation, Common (Peat)	200	CY	4.55	910	25	228	1,138
	Drilling and Blasting	2,900	CY	8.50	24,650	25	6,163	30,813
	Excavation and Hauling, Rock	2,900	CY	6.30	18,270	25	4,568	22,838
	Structural Backfill	1,700	CY	6.00	10,200	25	2,550	12,750
	Riprap Stone (18")	250	CY	40.00	10,000	20	2,000	12,000
	Bedding Stone (12")	180	CY	35.00	6,300	20	1,260	7,560
15.0.E.-	Foundation Work:							
15.0.E.B	Sitework							
	Piling, Steel Sheet	1,450	SF	30.00	43,500	25	10,875	54,375
	Safety Barriers	1	JOB	LS	8,000	20	1,600	9,600
15.0.1.-	Overflow Structure:							
15.0.1.C	Concrete							
	Concrete, in Place	138	CY	325.00	44,850	20	8,970	53,820
	Cement	735	CWT	5.00	3,675	20	735	4,410
	Reinforcing Steel	17,300	LBS	0.55	9,515	20	1,903	11,418
	Tremie Concrete	452	CY	200.00	90,400	25	22,600	113,000
15.0.1.N	Special Construction							
	Staff Gage Instruments	1	JOB	LS	2,000	15	300	2,300

Table 25 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 349A
(Costs are identical for Structures 349B & 349C)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES (Continued) Structure 349A							
15.0.3.-	Embedded Metal Work							
15.0.3.E	Metals							
	Handrails	140	LF	15.00	2,100	20	420	2,520
15.0.4.-	Gates and Associated Equipment							
15.0.4.E	Metals							
	Slide Gates (10′ x 12′, including Operating Machinery)	4	EA	77,000	308,000	20	61,600	369,600
	Subtotal, Construction Costs:				$792,000			
15.0.Z.-	Contingencies @ average of 21.2%						$168,000	
15.-.-.-	Floodway Control And Diversion Structures Total:							$960,000

Table 26

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 355A

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	306,000	77,000	383,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	1,068,000	267,000	1,335,000
	TOTAL CONSTRUCTION COST	1,374,000	344,000	1,718,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	117,000	29,000	146,000
31.-.-.-	CONSTRUCTION MANAGEMENT	96,000	24,000	120,000
	TOTAL COSTS (STRUCTURE 355A)	$1,587,000	$397,000	$1,984,000

Table 27

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 355B

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	306,000	77,000	383,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	1,068,000	267,000	1,335,000
	TOTAL CONSTRUCTION COST	1,374,000	344,000	1,718,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	117,000	29,000	146,000
31.-.-.-	CONSTRUCTION MANAGEMENT	96,000	24,000	120,000
	TOTAL COSTS (STRUCTURE 355B)	$1,587,000	$397,000	$1,984,000

Table 28

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 355A
(Costs are identical for Structure 355B)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 09.0.Z.-)	TOTAL PROJECT COST
09.-.-.-	CHANNELS AND CANALS Structure 355A							
09.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	17,000	25	4,250	21,250
09.0.3.- 09.0.3.B	CANALS: Site Work - Collector Canal for S-355 A							
	Excavation, Common	30,100	CY	4.55	136,955	25	34,239	171,194
	Drilling and Blasting	9,700	CY	8.50	82,450	25	20,613	103,063
	Excavation and Hauling, Rock	9,700	CY	6.30	61,110	25	15,278	76,388
	Clearing and Grubbing	5	ACRE	1,000	5,000	25	1,250	6,250
	Grassing	2.5	ACRE	1,500	3,750	25	938	4,688
	Subtotal, Construction Costs:				$306,000			
09.0.Z.-	Contingencies @ average of 25.2%						$77,000	
09.-.-.-	Channels And Canals Total:							$383,000

Table 28 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 355A
(Costs are identical for Structure 355B)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES Structure 355A							
15.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	60,000	25	15,000	75,000
15.0.B.-	Care and Diversion of Water							
15.0.B.B	Site Work							
	Cofferdam (S.S. Pile for Water Cutoff) Place and Remove	1	JOB	LS	136,000	25	34,000	170,000
15.0.B.C	Concrete							
	Tremie Concrete, in Place	770	CY	200.00	154,000	25	38,500	192,500
	Excavation for Tremie Concrete	770	CY	12.00	9,240	25	2,310	11,550
15.0.B.Q	Mechanical							
	Dewatering Cofferdam: Pumps and Assoc. Equipment	1	JOB	LS	57,000	25	14,250	71,250
15.0.D.-	Earthwork for Structures:							
15.0.D.B	Site Work							
	Excavation, Common	3,570	CY	4.55	16,244	25	4,061	20,304
	Drilling and Blasting	1,530	CY	8.50	13,005	25	3,251	16,256
	Excavation and Hauling	1,530	CY	6.30	9,639	25	2,410	12,049
	Structural Backfill	1,700	CY	5.00	8,500	25	2,125	10,625
	Riprap Stone (18")	200	CY	40.00	8,000	25	2,000	10,000
	Bedding Stone (12")	140	CY	35.00	4,900	25	1,225	6,125
	Guardrail	100	LF	18.00	1,800	25	450	2,250
15.0.E.-	Foundation Work:							
15.0.E.B	Site Work							
	Steel Sheetpiling	2,200	SF	23.00	50,600	25	12,650	63,250

Table 28 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Structure 355A
(Costs are identical for Structure 355B)

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES (Continued)							
	Structure 355A							
15.0.1.-	Overflow Structure:							
15.0.1.C	Concrete							
	Concrete, in Place	460	CY	325.00	149,500	25	37,375	186,875
	Reinforcing Steel	57,500	LBS	0.55	31,625	25	7,906	39,531
	Cement	2,500	CWT	5.00	12,500	25	3,125	15,625
15.0.1.N	Special Construction							
	Staff Gage Instruments	1	JOB	LS	2,000	25	500	2,500
15.0.3.-	Embedded Metal Work							
15.0.3.E	Metals							
	Handrail	370	LF	15.00	5,550	25	1,388	6,938
15.0.3.R	Electrical Work	1	JOB	LS	30,000	25	7,500	37,500
15.0.4.-	Gates and Associated Equipment							
15.0.4.E	Metals							
	Gates (2-Vertical Lift Gates)	2	EA	59,000	118,000	25	29,500	147,500
15.0.4.Q	Gate Operating Machinery	1	JOB	LS	120,000	25	30,000	150,000
15.0.R.-	Associated General Items:							
15.0.R.B	Site Work (Structure)							
	Pavement	500	SY	15.00	7,500	25	1,875	9,375
	Safety Barriers	1	JOB	LS	25,000	25	6,250	31,250
	Control House Fencing	200	LF	12.00	2,400	25	600	3,000
15.0.R.E	Metals							
	Misc. Structures, Control House/ Stilling Wells	1	JOB	LS	35,000	25	8,750	43,750
	Subtotal, Construction Costs:				$1,068,000			
15.0.Z.-	Contingencies @ average of 25.0%						$267,000	
15.-.-.-	Floodway Control And Diversion Structures Total:							$1,335,000

Table 29

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

New Spillway Structure S-334

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
11.-.-.-	LEVEES AND FLOODWALLS	303,000	74,000	377,000
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES	1,106,000	273,000	1,379,000
	TOTAL CONSTRUCTION COST	1,409,000	347,000	1,756,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	120,000	29,000	149,000
31.-.-.-	CONSTRUCTION MANAGEMENT	99,000	24,000	123,000
	TOTAL COSTS (NEW SPILLWAY STRUCTURE S-334)	$1,628,000	$400,000	$2,028,000

Table 30

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

New Spillway Structure S-334

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.-.-.-	LEVEES AND FLOODWALLS New Spillway Structure S-334							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	17,000	20	3,400	20,400
11.0.1.-	LEVEES							
11.0.1.B	Site Work							
	Clearing & Grubbing	6	ACRE	1,000	6,000	20	1,200	7,200
	Tieback Levee, from S-334 to L-31 N.	37,000	CY	7.40	273,800	25	68,450	342,250
	Grassing	4	ACRE	1,500	6,000	20	1,200	7,200
	Subtotal, Construction Costs:				$303,000			
11.0.Z.-	Contingencies @ average of 24.4%						$74,000	
11.-.-.-	Levees And Floodwalls Total:							$377,000

Table 30 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

New Spillway Structure S-334

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES New Spillway Structure S-334							
15.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	63,000	25	15,750	78,750
15.0.B.-	Care and Diversion of Water							
15.0.B.B	Site Work							
	Cofferdam (S.S. Pile for Water Cutoff) Place and Remove	1	JOB	LS	136,000	25	34,000	170,000
15.0.B.C	Concrete							
	Tremie Concrete, in Place	1	JOB	LS	150,000	25	37,500	187,500
15.0.B.Q	Mechanical							
	Dewatering Cofferdam: Pumps and Assoc. Equipment	1	JOB	LS	57,000	25	14,250	71,250
15.0.D.-	Earthwork for Structures:							
15.0.D.B	Site Work							
	Excavation, Common	1,800	CY	3.40	6,120	25	1,530	7,650
	Excavation, Rock	1,200	CY	12.00	14,400	25	3,600	18,000
	Structural Backfill	8,000	CY	5.00	40,000	25	10,000	50,000
	Riprap Stone (18")	180	CY	40.00	7,200	25	1,800	9,000
	Bedding Stone (12")	125	CY	35.00	4,375	25	1,094	5,469
	Guardrail	250	LF	18.00	4,500	25	1,125	5,625
15.0.E.-	Foundation Work:							
15.0.E.B	Site Work							
	Steel Sheetpiling	2,400	SF	23.00	55,200	25	13,800	69,000

Table 30 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
New Spillway Structure S-334

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES New Spillway Structure S-334							
15.0.1.-	Overflow Structure:							
15.0.1.C	Concrete							
	Concrete, in Place	320	CY	325.00	104,000	25	26,000	130,000
	Reinforcing Steel	40,000	LBS	0.55	22,000	25	5,500	27,500
	Cement	1,680	CWT	5.00	8,400	25	2,100	10,500
15.0.1.N	Special Construction							
	Staff Gages	1	JOB	LS	2,600	25	650	3,250
15.0.3.-	Embedded Metal Work							
15.0.3.E	Metals							
	Handrail	450	LF	10.00	4,500	25	1,125	5,625
15.0.3.R	Electrical Work	1	JOB	LS	30,000	25	7,500	37,500
15.0.4.-	Gates and Associated Equipment							
15.0.4.E	Metals							
	Remove Gates from Existing Structure	1	JOB	LS	10,000	25	2,500	12,500
	New Gates (2-Vertical Lift Gates)	2	EA	59,000	118,000	25	29,500	147,500
15.0.4.Q	Gate Operating Machinery	1	JOB	LS	120,000	25	30,000	150,000

Table 30 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
New Spillway Structure S-334

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 15.0.Z.-)	TOTAL PROJECT COST
15.-.-.-	FLOODWAY CONTROL AND DIVERSION STRUCTURES (Continued)							
	New Spillway Structure S-334							
15.0.R.-	Associated General Items:							
15.0.R.B	Site Work (Structure)							
	Pavement	1,800	SY	15.00	27,000	25	6,750	33,750
	Safety Barriers	1	JOB	LS	25,000	25	6,250	31,250
	Control House	1	JOB	LS	25,000	20	5,000	30,000
	Chain Link Fence	350	LF	10.00	3,500	25	875	4,375
	Grassing & Sodding	1	JOB	LS	10,000	25	2,500	12,500
	Embankment - Access Ramp for U.S. 41	700	CY	12.00	8,400	25	2,100	10,500
	Construction of Retaining Wall (for Road Fill)							
	Excavation	300	CY	6.00	1,800	25	450	2,250
	Backfill	300	CY	6.00	1,800	25	450	2,250
	Concrete Retaining Wall (for Road Fill)							
	Concrete	85	CY	325.00	27,625	20	5,525	33,150
	Reinforcing Steel	10,600	LBS	0.55	5,830	20	1,166	6,996
	Cement	450	CWT	5.00	2,250	20	450	2,700
15.0.R.E	Metals							
	Miscellaneous Metal	5,000	Lbs	2.00	10,000	25	2,500	12,500
	Subtotal, Construction Costs:				$1,106,000			
15.0.Z.-	Contingencies @ average of 24.7%						$273,000	
15.-.-.-	Floodway Control And Diversion Structures Total:							$1,379,000

Table 31

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

U.S. 41 Raising and Ramping

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
08.-.-.-	ROADS, RAILROADS AND BRIDGES			
08.2.-.-	ROADS	2,014,000	478,000	2,492,000
	TOTAL CONSTRUCTION COST	2,014,000	478,000	2,492,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	171,000	41,000	212,000
31.-.-.-	CONSTRUCTION MANAGEMENT	141,000	33,000	174,000
	TOTAL COSTS (U.S. 41 RAISING AND RAMPING)	$2,326,000	$552,000	$2,878,000

Table 32

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
U.S. 41 Raising and Ramping

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 08.2.Z.-)	TOTAL PROJECT COST
08.-.-.-	ROADS, RAILROADS AND BRIDGES							
08.2.-.-	ROADS							
08.2.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	114,000	25	28,500	142,500
08.2.1.-	Care of Traffic							
08.2.1.B	Site Work for Temp. Detour Road							
	Clearing	7	AC	1,000	7,000	20	1,400	8,400
	Embankment Select Fill	30,000	CY	7.80	234,000	25	58,500	292,500
	Bit. Pavement, Place & Remove	8,500	SY	12.00	102,000	20	20,400	122,400
	6 inch Painted Stripes	9,000	LF	0.25	2,250	20	450	2,700
	Guard Rail, Install & Remove	6,000	LF	15.00	90,000	20	18,000	108,000
08.2.2.-	Construct Roadbed to Subgrade							
08.2.2.B	Site Work - U.S. 41 (Permanent)							
	Clearing and Grubbing	3.5	ACRE	1,000	3,500	25	875	4,375
	Pavement Removal	11,000	SY	3.00	33,000	20	6,600	39,600
	Embankment, Select Fill	35,000	CY	13.00	455,000	25	113,750	568,750
	Topsoil	2,500	CY	12.00	30,000	25	7,500	37,500
	Sheetpile Retaining Wall (W/Tiebacks)	30,000	SF	22.00	660,000	25	165,000	825,000

Table 32 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
U.S. 41 Raising and Ramping

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 08.2.Z.-)	TOTAL PROJECT COST
08.-.-.-	ROADS, RAILROADS AND BRIDGES (Continued)							
08.2.-.-	ROADS							
08.2.3.-	Road Surfacing (U.S. 41)							
08.2.3.B	Site Work							
	Base Course	2,000	CY	30.00	60,000	20	12,000	72,000
	Asphaltic Concrete Pavement	11,000	SY	12.00	132,000	20	26,400	158,400
	6 inch Thermoplastic Stripes	9,000	LF	0.75	6,750	20	1,350	8,100
08.2.R.-	Associated General Items							
08.2.R.B	Site Work							
	Remove & Reinstall Guardrail	6,000	LF	12.00	72,000	20	14,400	86,400
	Grassing	0.5	ACRE	1,500	750	25	188	938
	Sodding	2,000	SY	6.00	12,000	25	3,000	15,000
	Subtotal, Construction Costs:				$2,014,000			
08.2.Z.-	Contingencies @ average of 23.7%						$478,000	
08.2.-.-	Roads, Railroads And Bridges Total:							$2,492,000

Table 33

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Pumping Station S-356

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
09.-.-.-	CHANNELS AND CANALS	745,000	186,000	931,000
11.-.-.-	LEVEES AND FLOODWALLS	412,000	103,000	515,000
13.-.-.-	PUMPING PLANT	9,320,000	5,144,000	14,464,000
	TOTAL CONSTRUCTION COST	10,477,000	5,433,000	15,910,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	891,000	462,000	1,353,000
31.-.-.-	CONSTRUCTION MANAGEMENT	733,000	380,000	1,113,000
	TOTAL COSTS (PUMPING STATION S-356)	$12,101,000	$6,275,000	$18,376,000

Table 34

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Pumping Station S-356

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 09.0.Z.-)	TOTAL PROJECT COST
09.-.-.-	CHANNELS AND CANALS Pumping Station S-356							
09.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	42,000	25	10,500	52,500
09.0.3.-	CANALS							
09.0.3.B	Site Work							
	Clearing	5.5	ACRE	1,000	5,500	20	1,100	6,600
	Canal Excavation, Peat	31,000	CY	6.90	213,900	25	53,475	267,375
	Canal Excavation, Rock	43,000	CY	11.25	483,750	25	120,938	604,688
	Subtotal, Construction Costs:				$745,000			
09.0.Z.-	Contingencies @ average of 25.0%						$186,000	
09.-.-.-	Channels And Canals Total:							$931,000

Table 34 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Pumping Station S-356

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.-.-.-	LEVEES AND FLOODWALLS Pumping Station S-356							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	23,000	25	5,750	28,750
11.0.1.-	LEVEES							
11.0.1.B	Site Work							
	Clearing	2.5	ACRE	1,000	2,500	20	500	3,000
	Levee Fill, Outer Levee	50,000	CY	5.60	280,000	25	70,000	350,000
	Levee Fill, Tieback Levee	18,000	CY	5.60	100,800	25	25,200	126,000
	Grassing	4	ACRE	1,500	6,000	20	1,200	7,200
	Subtotal, Construction Costs:				$412,000			
11.0.Z.-	Contingencies @ average of 25.0%						$103,000	
11.-.-.-	Levees And Floodwalls Total:							$515,000

Table 34 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Pumping Station S-356

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 13.0.Z.-)	TOTAL PROJECT COST
13.-.-.-	PUMPING PLANT Pumping Station S-356							
13.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	800,000	25	200,000	1,000,000
13.0.B.-	Care and Diversion of Water:							
13.0.B.B	Sitework							
	Steel Sheetpile Cofferdam	17,300	SF	23.00	397,900	25	99,475	497,375
	Rock Anchors	1,700	LF	60.00	102,000	25	25,500	127,500
	Tremie Concrete	2,200	CY	150.00	330,000	25	82,500	412,500
13.0.B.Q	Mechanical							
	Dewatering & Pumping	1	JOB	LS	167,000	25	41,750	208,750
13.0.C.-	Permanent Access Roads & Parking:							
13.0.C.B	Sitework							
	Access Road, Pavement, Drainage	3,360	SY	25.00	84,000	25	21,000	105,000
	Landscaping	1	JOB	LS	11,000	25	2,750	13,750
	Sodding	1,000	SY	5.00	5,000	25	1,250	6,250
	Grassing	2	ACRE	2000.00	4,000	25	1,000	5,000
	Guardrail	1,400	LF	20.00	28,000	25	7,000	35,000
13.0.D.-	Earthwork for Structures:							
13.0.D.B	Sitework							
	Excavation for Structures	1	JOB	LS	54,000	25	13,500	67,500
	Excavation for Channel	1	JOB	LS	157,000	25	39,250	196,250
	Fill & Backfill	1	JOB	LS	234,000	25	58,500	292,500
	Stone Protection	300	CY	40.00	12,000	25	3,000	15,000
13.0.E.-	Foundation Work:							
13.0.E.B	Sitework							
	Steel Sheetpiling PZ-27	2,700	SF	30.00	81,000	25	20,250	101,250
13.0.1.-	Pumping Plant Substructure:							
13.0.1.C	Concrete							
	Concr., in Place Inc. Cement & Re-Steel	3,800	CY	250.00	950,000	25	237,500	1,187,500

Table 34 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Pumping Station S-356

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 13.0.Z.-)	TOTAL PROJECT COST
13.-.-.-	PUMPING PLANT (Continued)							
	Pumping Station S-356							
13.0.2.-	Pumping Plant Superstructure:	1	JOB	LS	2,850,000	67.6	1,926,600	4,776,600
13.0.3.-	Pumping Machinery and Appurtenances:							
13.0.3.Q	Mechanical							
	Main Pumps	1	JOB	LS	1,129,200	59.4	670,745	1,799,945
	Main Pump Diesel Engines	1	JOB	LS	150,000	900.0	1,350,000	1,500,000
	Main Pump Transmission Gears	1	JOB	LS	376,800	20	75,360	452,160
	Spares	1	JOB	LS	16,000	20	3,200	19,200
	Services of Erecting Engineer	1	JOB	LS	74,000	20	14,800	88,800
	Model Study	1	JOB	LS	210,000	20	42,000	252,000
	Station Costs	1	JOB	LS	767,000	20	153,400	920,400
13.0.3.R	Electrical	1	JOB	LS	261,000	14.7	38,367	299,367
13.0.6.-	Utilities							
13.0.6.Q	Mechanical							
	Sanitary Sewer & Storm Drain	1	JOB	LS	35,000	25	8,750	43,750
13.0.R.-	Associated General Items:							
13.0.R.B	Sitework							
	Fencing, Chain Link	1	JOB	LS	34,000	20	6,800	40,800
	Subtotal, Construction Costs:				$9,320,000			
13.0.Z.-	Contingencies @ average of 55.2%						$5,144,000	
13.-.-.-	Pumping Plant Total:							$14,464,000

Table 35

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Degrading of Levee L-67 Extension

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
11.-.-.-	LEVEES AND FLOODWALLS	2,585,000	525,000	3,110,000
	TOTAL CONSTRUCTION COST	2,585,000	525,000	3,110,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	220,000	45,000	265,000
31.-.-.-	CONSTRUCTION MANAGEMENT	181,000	37,000	218,000
	TOTAL COSTS (DEGRADING OF LEVEE L-67 EXTENSION)	$2,986,000	$607,000	$3,593,000

Table 36

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Degrading of Levee L-67 Extension

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.-.-.-	LEVEES AND FLOODWALLS Degrading of Levee L-67 Extension							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	146,000	25	36,500	182,500
11.0.1.- 11.0.1.B	LEVEES Site Work							
	Levee Degrading	780,000	CY	3.10	2,418,000	20	483,600	2,901,600
	Culvert S-346 Removal	1	JOB	LS	7,000	25	1,750	8,750
	Culvert S-347 Removal	1	JOB	LS	7,000	25	1,750	8,750
	Culvert #4 Removal	1	JOB	LS	7,000	25	1,750	8,750
	Subtotal, Construction Costs:				$2,585,000			
11.0.Z.-	Contingencies @ average of 20.3%						$525,000	
11.-.-.-	Levees And Floodwalls Total:							$3,110,000

Table 37

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Flood Protection to Residential Area

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
02.-.-.-	RELOCATIONS	1,715,000	429,000	2,144,000
08.-.-.-	ROADS, RAILROADS AND BRIDGES			
08.2.-.-	ROADS	700,000	143,000	843,000
09.-.-.-	CHANNELS AND CANALS	6,972,000	1,743,000	8,715,000
11.-.-.-	LEVEES AND FLOODWALLS	3,676,000	919,000	4,595,000
	TOTAL CONSTRUCTION COST	13,063,000	3,234,000	16,297,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	1,110,000	275,000	1,385,000
31.-.-.-	CONSTRUCTION MANAGEMENT	914,000	226,000	1,140,000
	TOTAL COSTS (FLOOD PROTECTION TO RESIDENTIAL AREA)	$15,087,000	$3,735,000	$18,822,000

Table 38

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Flood Protection to Residential Area

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 02.3.Z.-)	TOTAL PROJECT COST
02.-.-.-	RELOCATIONS Flood Protection to Residential Area							
02.3.-.-	Construction Activities							
	Debris Removal	10,000	CY	85.00	850,000	25	212,500	1,062,500
	Automobiles (100), Home Appliances,Large (100), Tires (1,000) and misc	1	JOB	LS	72,000	25	18,000	90,000
	Degrading Existing Roads(Approx 26 mi)	64,000	CY	12.00	768,000	25	192,000	960,000
	House and Foundation Removal (Approx 100' x 100')	4	EA	6,250	25,000	25	6,250	31,250
	Subtotal, Construction Costs:				$1,715,000			
02.3.Z.-	Contingencies @ average of 25.0%						$429,000	
02.3.-.-	Relocations Total:							$2,144,000

Table 38 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Flood Protection to Residential Area

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 08.2.Z.-)	TOTAL PROJECT COST
08.-.-.-	ROADS, RAILROADS AND BRIDGES Flood Protection to Residential Area							
08.2.-.-	ROADS (Access Road to S-357 Pumping Station)							
08.2.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	58,000	25	14,500	72,500
08.2.2.- 08.2.2.B	Construct Roadbed to Subgrade Site Work Stripping for Road to Establish Road Bed	10,500	CY	1.00	10,500	25	2,625	13,125
08.2.3.- 08.2.3.B	Road Surfacing Site Work Pavement for Road	31,560	SY	20.00	631,200	20	126,240	757,440
	Subtotal, Construction Costs:				$700,000			
08.2.Z.-	Contingencies @ average of 20.4%						$143,000	
08.2.-.-	Roads, Railroads And Bridges Total:							$843,000

Table 38 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Flood Protection to Residential Area

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 09.0.Z.-)	TOTAL PROJECT COST
09.-.-.-	CHANNELS AND CANALS Flood Protection to Residential Area							
09.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	334,000	25	83,500	417,500
09.0.3.-	CANALS							
09.0.3.B	Site Work							
	Clearing	100	ACRE	1,000	100,000	25	25,000	125,000
	Drilling and Blasting	496,000	CY	8.50	4,216,000	25	1,054,000	5,270,000
	Excavation and Hauling (Rock)	496,000	CY	4.50	2,232,000	25	558,000	2,790,000
	Grassing	60	ACRE	1,500	90,000	25	22,500	112,500
	Subtotal, Construction Costs:				$6,972,000			
09.0.Z.-	Contingencies @ average of 25.0%						$1,743,000	
09.-.-.-	Channels And Canals Total:							$8,715,000

Table 38 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Flood Protection to Residential Area

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 11.0.Z.-)	TOTAL PROJECT COST
11.- .-.-	LEVEES AND FLOODWALLS Flood Protection to Residential Area							
11.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	208,000	25	52,000	260,000
11.0.1.-	LEVEES							
11.0.1.B	Site Work							
	Clearing & Grubbing	160	ACRE	1,000	160,000	25	40,000	200,000
	Inner Levee Embankment	159,000	CY	2.80	445,200	25	111,300	556,500
	Low Outer Levee Embankment	192,000	CY	2.80	537,600	25	134,400	672,000
	Geotextile Blanket	168,000	SY	8.25	1,386,000	25	346,500	1,732,500
	3 ft Thick Fill Layer (from excav canal)	23,000	CY	2.80	64,400	25	16,100	80,500
	3 ft Thick Fill Layer (from L-31N disposal bank)	145,000	CY	5.00	725,000	25	181,250	906,250
	Grassing	100	ACRE	1,500	150,000	25	37,500	187,500
	Subtotal, Construction Costs:				$3,676,000			
11.0.Z.-	Contingencies @ average of 25.0%						$919,000	
11.- .-.-	Levees And Floodwalls Total:							$4,595,000

Table 39

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Miccosukee Indian - Tiger Tail Camp Mitigation

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES	301,000	67,000	368,000
	TOTAL CONSTRUCTION COST	301,000	67,000	368,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	35,000	8,000	43,000
31.-.-.-	CONSTRUCTION MANAGEMENT	14,000	3,000	17,000
	TOTAL COSTS (MICCOSUKEE INDIAN - TIGER TAIL CAMP MITIGATION)	$350,000	$78,000	$428,000

Table 40

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Miccosukee Indian - Tiger Tail Camp Mitigation

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 19.0.Z.-)	TOTAL PROJECT COST
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES Miccosukee Indian - Tiger Tail Camp Mitigation							
19.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	17,000	25	4,250	21,250
19.0.3.-	Site Grading and Landscaping							
19.0.3.B	Site Work							
	Clearing and Grubbing	1.5	ACRE	1,000	1,500	25	375	1,875
	Embankment, Select Fill	8,500	CY	5.00	42,500	25	10,625	53,125
	Grassing	1.0	ACRE	1,500.00	1,500	25	375	1,875
	Trees and Shrubs	1	JOB	LS	5,000	25	1,250	6,250
	Riprap (12" thick)	150.0	CY	40.00	6,000	25	1,500	7,500
19.0.4.-	Utilities Treatment							
19.0.4.Q	Mechanical							
	Septic Tank	1	JOB	LS	2,000	20	400	2,400
	Leaching Field	1	JOB	LS	9,200	20	1,840	11,040
	Retaining Wall	1	JOB	LS	2,500	20	500	3,000
	Septic Counter Weight	5	CY	200.00	1,000	20	200	1,200
19.0.5.-	Utilities, Lines and Services							
19.0.5.B	Site Work							
	New Well	100	FT	18.00	1,800	20	360	2,160
	Abandon Existing Well	1	JOB	LS	500	20	100	600
19.0.5.Q	Mechanical							
	Pumps/Controllers	1	JOB	LS	1,000	20	200	1,200
	Piping, Water	1,500	LF	1.75	2,625	20	525	3,150
	Piping, Sewage	1,500	LF	2.50	3,750	20	750	4,500
	Pumps, Dosing	1	JOB	LS	500	20	100	600
	Tanks, Pressure	1	EA	300.00	300	20	60	360
	Box, Dosing	1	EA	500.00	500	20	100	600

Table 40 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Miccosukee Indian - Tiger Tail Camp Mitigation

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 19.0.Z.-)	TOTAL PROJECT COST
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES (Continued)							
	Miccosukee Indian - Tiger Tail Camp Mitigation							
19.0.5.-	Utilities, Lines and Services							
19.0.5.R	Electrical							
	Temporary Service Connections	6	EA	200.00	1,200	20	240	1,440
	Permanent Service Connection, 100 Amp	6	EA	500.00	3,000	20	600	3,600
	Pump Hookup	1	JOB	LS	1,000	20	200	1,200
	Area Lighting	1	JOB	LS	500	20	100	600
19.0.P.-	Buildings, Public Use							
19.0.P.F	Wood and Plastic Docks	120	SF	10.00	1,200	25	300	1,500
19.0.Q.-	Buildings, Residences and Dormitories							
19.0.Q.B	Site Work							
	Demolition and Removal of Existing Structures	1	JOB	LS	15,000	25	3,750	18,750
	New Construction							
	Chickee Housing	550	SF	10.00	5,500	25	1,375	6,875
	Modified Chickee	1,200	SF	35.00	42,000	25	10,500	52,500
19.0.Q.E	Pre-Engineered Buildings							
	Mobile Home Purchase (60' x 12')	6	EA	22,000	132,000	20	26,400	158,400
	Subtotal, Construction Costs:				$301,000			
19.0.Z.-	Contingencies @ average of 22.3%						$67,000	
19.-.-.-	Buildings, Grounds And Utilities Total:							$368,000

Table 41

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Miccosukee Indian - Osceloa Camp Mitigation

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES	201,000	49,000	250,000
	TOTAL CONSTRUCTION COST	201,000	49,000	250,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	34,000	8,000	42,000
31.-.-.-	CONSTRUCTION MANAGEMENT	14,000	3,000	17,000
	TOTAL COSTS (MICCOSUKEE INDIAN - OSCEOLA CAMP MITIGATION)	$249,000	$60,000	$309,000

Table 42

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Miccosukee Indian - Osceola Camp Mitigation

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 19.0.Z.-)	TOTAL PROJECT COST
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES Miccosukee Indian - Osceola Camp Mitigation							
19.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	17,000	25	4,250	21,250
19.0.3.-	Site Grading and Landscaping							
19.0.3.B	Site Work							
	Clearing and Grubbing	1.5	ACRE	1,000	1,500	25	375	1,875
	Embankment, Select Fill	8,200	CY	5.00	41,000	25	10,250	51,250
	Grassing	1.5	ACRE	1,500.00	2,250	25	563	2,813
	Trees and Shrubs	1	JOB	LS	5,000	25	1,250	6,250
	Fence and Gates (Wood)	911.0	SF	3.50	3,189	25	797	3,986
	Remove and Install Pavement (Ent Apron)	500.0	SY	26.00	13,000	25	3,250	16,250
19.0.4.-	Utilities Treatment							
19.0.4.Q	Mechanical							
	Septic Tank	1	JOB	LS	2,000	20	400	2,400
	Drainfield	1	JOB	LS	3,000	20	600	3,600
	Septic Counter Weight	5	CY	200.00	1,000	20	200	1,200
19.0.5.-	Utilities, Lines and Services							
19.0.5.B	Site Work							
	New Well	100	FT	18.00	1,800	20	360	2,160
	Abandon Existing Well	1	JOB	LS	500	20	100	600
19.0.5.Q	Mechanical							
	Pumps/Controllers	1	JOB	LS	1,000	20	200	1,200
	Piping, Water	500	LF	1.75	875	20	175	1,050
	Piping, Sewage	500	LF	2.50	1,250	20	250	1,500
	Pumps, Dosing	1	JOB	LS	500	20	100	600
	Tanks, Pressure	1	EA	300.00	300	20	60	360
	Box, Dosing	1	EA	500.00	500	20	100	600

Table 42 (Continued)

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Miccosukee Indian - Osceola Camp Mitigation

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 19.0.Z.-)	TOTAL PROJECT COST
19.-.-.-	BUILDINGS, GROUNDS AND UTILITIES (Continued) Miccosukee Indian - Osceola Camp Mitigation							
19.0.5.-	Utilities, Lines and Services							
19.0.5.R	Electrical							
	Temporary Service Connections	2	EA	200.00	400	20	80	480
	Permanent Service Connection, 100 Amp	2	EA	500.00	1,000	20	200	1,200
	Pump Hookup	1	JOB	LS	1,000	20	200	1,200
	Area Lighting	1	JOB	LS	500	20	100	600
	Elevate Electric Lines/Poles (6)	1	JOB	LS	10,200	25	2,550	12,750
	Telephone Service Connections (2)	1	JOB	LS	300	25	75	375
19.0.Q.-	Buildings, Residences and Dormitories							
19.0.Q.B	Site Work							
	Demolition and Removal of Existing Structures	1	JOB	LS	15,000	25	3,750	18,750
	New Construction							
	Chickee Housing	990	SF	10.00	9,900	25	2,475	12,375
	Modified Chickee	1,540	SF	35.00	53,900	25	13,475	67,375
	Frame Housing	172	SF	35.00	6,020	25	1,505	7,525
19.0.Q.E	Pre-Engineered Buildings							
	Mobile Home Lease (60' x 12')	2	EA	3,600	7,200	20	1,440	8,640
	Subtotal, Construction Costs:				$201,000			
19.0.Z.-	Contingencies @ average of 24.4%						$49,000	
19.-.-.-	Buildings, Grounds And Utilities Total:							$250,000

Table 43

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Pumping Station S-357

SUMMARY

ACCOUNT CODE	ITEM	Estimated Cost	Contingency	Total Cost
13.-.-.-	PUMPING PLANT	4,107,000	874,000	4,981,000
	TOTAL CONSTRUCTION COST	4,107,000	874,000	4,981,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	349,000	74,000	423,000
31.-.-.-	CONSTRUCTION MANAGEMENT	287,000	61,000	348,000
	TOTAL COSTS (PUMPING STATION S-357)	$4,743,000	$1,009,000	$5,752,000

Table 44

FEBRUARY, 1991 PRICE LEVEL

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK
Pumping Station S-357

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY (In acct. 13.0.Z.-)	TOTAL PROJECT COST
13.-.-.-	PUMPING PLANT Pumping Station S-357							
13.0.A.-	Mobilization & Demobilization and Preparatory Work	1	JOB	LS	400,000	25	100,000	500,000
13.0.B.- 13.0.B.B	Care and Diversion of Water: Sitework Cofferdam	23,000	SF	23.00	529,000	25	132,250	661,250
13.0.D.- 13.0.D.B	Earthwork for Structures: Sitework							
	Excavation	1	JOB	LS	428,000	25	107,000	535,000
	Stone Protection	270	CY	40.00	10,800	25	2,700	13,500
	Access Road, etc.	10,000	SY	25.00	250,000	25	62,500	312,500
	Sodding	720	SY	5.00	3,600	25	900	4,500
	Concrete, inc. Cement & Re-Steel	725	CY	300.00	217,500	25	54,375	271,875
13.0.E.- 13.0.E.B	Foundation Work: Sitework Steel Sheetpiling PZ-27	1,600	SF	30.00	48,000	25	12,000	60,000
13.0.1.-	Pumping Plant Substructure & Superstruct:	1	JOB	LS	438,000	25	109,500	547,500
13.0.3.- 13.0.3.Q	Pumping Machinery and Appurtenances: Mechanical							
	Total Supply Contract	1	JOB	LS	907,500	11.6	105,270	1,012,770
	Station Equipment	1	JOB	LS	500,000	25	125,000	625,000
13.0.3.R	Electrical	1	JOB	LS	375,000	16.7	62,625	437,625
	Subtotal, Construction Costs:				$4,107,000			
13.0.Z.-	Contingencies @ average of 21.3%						$874,000	
13.-.-.-	Pumping Plant Total:							$4,981,000

Table 45

Structures 345A, B, & C

Summary of Hydraulic Design Data*

Location	Levee 67A
Station	440+00, 640+00, 845+00
Design Condition	
Discharge (cfs)	500
HW Elevation	9.4
TW Elevation	7.9
Culvert	
Type	C.M.P.
Number	3
Diameter (inches)	72
Length (feet)	85
Invert Elevation	0.0
Type of Control	Slide Gate
Riprap	
Length (feet)	10
Protection Elevation	10.9
Canal Section	
Side Slopes (vert. on hor.)	1 on 3
Upstream Bottom Width & Elevation	30′ B.W., -0.5
Downstream Bottom Width & Elevation	30′ B.W., -0.5
Approx. Ground Elevation @ Structure	6.0
Protection Elev.	Top of existing levee (approx. 18.0)

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 46

Gated Water Control Structures 349A, B, & C

Summary of Hydraulic Design Data*

Location	L-67A Borrow Canal
Station	439+00, 639+00, 844+00
Design Condition	
Discharge (cfs)	1,250
HW Elevation	7.2
TW Elevation	7.0
SPF Condition	
Discharge (cfs)	1,250
Headwater	7.2
Tailwater	7.0
Optimum Condition	
Headwater	7.2
Tailwater	7.0
Stilling Basin	No stilling basin needed
Crest	Sheet pile wall with vertical slide gates mounted on the face of the wall
Gates	
Number	4
Width x height (ft.)	12.0 x 10.0
Clearance Elevation	6.0
Invert Elevation	-4.0
Instrumentation	
HW Recorder & Staff Gage	40-feet upstream
TW Recorder & Staff Gage	100-feet downstream
Gate Position Recorders	No
Channel Section	
Upstream Bottom Width (ft.)	65
Upstream Bottom Elevation	-8
Upstream Side Slopes	1 on 1
Downstream Bottom Width (ft.)	65
Downstream Bottom Elevation	-8
Downstream Side Slopes	1 on 1

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 47

Structures 345A, B, & C

Summary of Hydraulic Design Data*

Location	Levee 67A
Station	440+00, 640+00, 845+00
Design Condition	
Discharge (cfs)	500
HW Elevation	9.4
TW Elevation	7.9
Culvert	
Type	C.M.P.
Number	3
Diameter (inches)	72
Length (feet)	85
Invert Elevation	0.0
Type of Control	Slide Gate
Riprap	
Length (feet)	10
Protection Elevation	10.9
Canal Section	
Side Slopes (vert. on hor.)	1 on 3
Upstream Bottom Width & Elevation	30′ B.W., -0.5
Downstream Bottom Width & Elevation	30′ B.W., -0.5
Approx. Ground Elevation @ Structure	6.0
Protection Elev.	Top of existing levee (approx. 18.0)

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 48

Gated Water Control Structures 349A, B, & C

Summary of Hydraulic Design Data*

Location	L-67A Borrow Canal
Station	439+00, 639+00, 844+00
Design Condition	
Discharge (cfs)	1,250
HW Elevation	7.2
TW Elevation	7.0
SPF Condition	
Discharge (cfs)	1,250
Headwater	7.2
Tailwater	7.0
Optimum Condition	
Headwater	7.2
Tailwater	7.0
Stilling Basin	No stilling basin needed
Crest	Sheet pile wall with vertical slide gates mounted on the face of the wall
Gates	
Number	4
Width x height (ft.)	12.0 x 10.0
Clearance Elevation	6.0
Invert Elevation	-4.0
Instrumentation	
HW Recorder & Staff Gage	40-feet upstream
TW Recorder & Staff Gage	100-feet downstream
Gate Position Recorders	No
Channel Section	
Upstream Bottom Width (ft.)	65
Upstream Bottom Elevation	-8
Upstream Side Slopes	1 on 1
Downstream Bottom Width (ft.)	65
Downstream Bottom Elevation	-8
Downstream Side Slopes	1 on 1

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 49

Spillway Structures S-355A & B

Summary of Hydraulic Design Data*

Location	Levee 29
Stations	183+00, 307+00
Design conditions	
Gate design	
Discharge (c.f.s.)	1000
Headwater elevation	9.2
Tailwater elevation	8.9
Stilling basin design	
Discharge (c.f.s.)	1000
Headwater elevation	9.2
Tailwater elevation	8.9
S.P.F. Condition	
Discharge (c.f.s.)	1000
Headwater elevation	10.0
Tailwater elevation	9.7
Optimum condition	
Headwater elevation	9.2
Tailwater elevation	8.9
Crest	
Shape	Ogee
Elevation	1.8
Design head(Hd)(ft.)	7.4
Net length (ft.)	40
Gates	
Number	2
Width x height (ft.)	20x8.4
Clearance elevation	10.2
Instrumentation	
Headwater recorder & staff gage	30-feet upstream
Tailwater recorder & staff gage	30-feet downstream
Gate position recorders	at structure
Stilling Basin	
Elevation	0.0
Length	20
Endsill elevation	0.75
Baffle block elevation	1.0
Rows of baffle blocks	1
Training wall elevation	8.9

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 49 (continued)

Spillway Structures S-355A & B

Channel Section	
Upstream bottom width (ft.)	60
Upstream bottom elevation	0.0
Upstream side slopes	1 on 3
Downstream bottom width (ft.)	Existing
Downstream bottom elevation	"
Downstream side slopes	"
Upstream Riprap	
Length (ft.)	10.0
Protection elevation	12.0
Downstream Riprap	
Length (ft.)	10.0
Protection elevation	11.0
Protection elevation (Top of Existing Levee Approx.	15.0)

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 50

Structure S-334 Replacement

Summary of Hydraulic Design Data*

Location	1,800 Foot West of L-31N on L-29 Borrow Canal
Station	20+00
Design conditions	
Gate design	
Discharge (c.f.s.)	1,230
Headwater elevation	5.0
Tailwater elevation	4.7
Stilling basin design	
Discharge (c.f.s.)	1,230
Headwater elevation	5.0
Tailwater elevation	4.7
S.P.F. Condition	
Discharge (c.f.s.)	0.0
Headwater elevation	14.5
Tailwater elevation	5.0
Optimum condition	
Headwater elevation	5.0 to 6.5
Tailwater elevation	5.0
Crest	
Shape	Ogee
Elevation	-6.9
Net length (ft.)	29
Gates	
Number	1
Width x height (ft.)	29 x 24.3
Clearance elevation	6.0
Instrumentation	
Headwater recorder & staff gage	Station 21+00
Tailwater recorder & staff gage	Station 18+00
Gate position recorders	At Structure
Stilling Basin	
Elevation	-8.0
Length	28 Feet
Endsill elevation	-7.0
Baffle block elevation	-6.9
Rows of baffle blocks	One
Training wall elevation	4.7

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 50 (continued)

Structure S-334 Replacement

Channel Section	
Upstream bottom width (ft.)	60.0
Upstream bottom elevation	-7.0
Upstream side slopes	1 Vertical on 2 Horizontal
Downstream bottom width (ft.)	60.0
Downstream bottom elevation	-7.0
Downstream side slopes	1 Vertical on 2 Horizontal
Upstream Riprap	
Length (ft.)	7.0
Protection elevation	14.0
Downstream Riprap	
Length (ft.)	9.0
Protection elevation	9.0
Protection elevation	17.4

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 51

Pumping Station S-356

Summary of Hydraulic Design Data*

Location	Levee 29 Borrow Canal
Station	15+00
Design Conditions	
Design Pumping Capacity (CFS)	950
Estimated Average Annual Pumping (AF)	72,000
Design Head (feet)	5.5
Normal Head (feet)	2.5 to 3.0
Intake Water Surface Elevation	
Maximum Pumping	7.0
Maximum Non-pumping	5.5
Start Pumping	5.5
Normal Drawdown	5.0
Minimum Non-Pumping	3.5
Minimum Drawdown	4.5
Discharge Water Surface Elevation	
SPF (SPF plus wind setup and wave runup is 17.4)	14.5
Maximum Pumping	10.5
Normal Pumping	7.5 to 8.0
Minimum Non-Pumping	4.5
Intake Channel Section	
Invert Elevation	-7.0 to -8.5
Bottom Width (feet)	77
Side Slopes	1V:2H
Discharge Channel Section	
Invert Elevation	-10.5 to -7.0
Bottom Width (feet)	77
Side Slopes	1V:2H

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 52

Pumping Station S-357

Summary of Hydraulic Design Data*

Location	residential canal 240 feet from L-31N
Discharge Capacity (cfs)	533
Average Annual Volume (acre-feet)	54,000
Design Head	
Normal (feet)	1.4-1.7
Standard Project Flood (feet)	0.3
Intake Water-Surface Elevations	
Maximum Pumping	8.8
Maximum Nonpumping	5.7
Start Pumping	5.7
Normal Drawdown Pumping	5.7
Minimum Drawdown Pumping	4.5
Minimum Nonpumping	2.0
Discharge Water-Surface Elevations	
Standard Project Flood	9.1
Maximum Pumping	9.1
Normal Pumping	6.7
Minimum Pumping	4.7
Minimum Nonpumping	2.0
Intake Canal Section	
Invert Elevation	-6.3
Bottom Width (feet)	40
Side Slopes	1V:1H
Discharge Canal Section	
Invert Elevation	-6.3
Bottom Width (feet)	40
Side Slopes	1V:1H

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 53

Canal for Recommended Plan G

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet,NGVD)[2]	Bottom Elevation (feet,NGVD)	Bottom Width (feet)[3]
A-B	1000	533	6.70	-6.3	40
B-C	3780	533	5.70	-6.3	40
C-D	4619	428	5.79	-6.3	30
D-D1	3000	428	5.95	-6.3	30
D1-E	4920	309	6.07	-5.0	25
E-F	5259	222	6.07	-3.5	20
F-G	3038	145	6.21	-3.0	20
G-G1	2284	110	6.24	-3.0	10
G1-H	3325	74	6.30	-3.0	5
H-I	921	37	6.37	0.0	5
I-I1	2175	28	6.43	0.0	5
I1-J	3435	14	6.49	0.0	"Vee"

NOTES:
1. Stationing starts at the West side of L-31N.
2. There is 70 feet of concrete lined channel required, from the discharge side of S-357 to L-31N.
3. Canal side slopes are 1V:1H.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 54

Residential Area Canals For Plans A and B

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet, NGVD)[2]	Bottom Elevation (feet, NGVD)	Bottom Width (feet)[3]
A-B	2,600	15	7.2	4.0	5
B-C	3,150	58	7.0	1.5	10
C-D	3,100	135	6.9	0.5	10
D-H	3,700	216	5.7	-0.5	25
E-F	3,200	38	6.6	1.0	5
F-G	1,800	83	5.3	1.0	10
I-J	3,050	6	6.7	4.5	5
H-G	2,650	254	5.3	-1.5	30
G-J	2,600	371	5.2	-1.5	30
K-L	3,000	6	6.8	4.5	5
L-M	2,900	18	6.7	3.0	5
M-N	3,000	43	6.5	1.0	5
N-O	2,800	87	6.3	0.5	10
P-Q	2,800	21	6.7	3.0	5
Q-O	3,000	64	6.6	0.5	5
O-V	2,700	194	5.5	-1.5	15
R-S	2,600	34	5.9	1.5	5
S-T	2,600	100	5.8	0.0	10
T-U	2,600	165	5.6	-0.5	15
U-V	2,600	229	5.4	-1.5	25
V-W	2,700	380	5.3	-2.5	30
W-J	2,600	420	5.2	-2.5	30

1. See the above titled plate for the reach location.
2. Elevation at the upstream end of the reach.
3. Side slopes 1 on 1.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 55

Agricultural Area Canals for Plan B

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet, NGVD)[2]	Bottom Elevation (feet, NGVD)	Bottom Width (feet)[3]
A-B	2,770	25	6.3	1.5	5
B-C	3,150	74	6.2	1.0	20
C-D	3,080	124	6.1	0.8	35
D-E	3,140	174	6.0	0.8	45
E-F	3,050	219	5.9	0.0	45
F-G	2,650	258	5.8	-0.2	55
G-H	2,630	298	5.7	-0.2	55
H-I	2,630	347	5.6	-0.8	60
I-J	2,000	374	5.5	-0.8	60
K-L	4,180	22	6.4	2.2	5
L-J	2,600	89	6.0	0.8	20
J-M	300	404	5.4	-0.8	60

1. See the above titled plate for the reach location.
2. Elevation at the upstream end of the reach.
3. Side slopes 1 on 1.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 56

Canals for Plan C

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet, NGVD)[2]	Bottom Elevation (feet, NGVD)	Bottom Width (feet)[3]
A-B	2,600	24	7.3	3.0	5
B-C	3,150	98	7.1	0.0	10
C-D	3,100	245	7.0	-1.0	15
E-F	3,200	98	6.6	1.0	15
F-G	1,800	195	5.3	-1.0	15
D-H	3,700	360	5.5	-1.0	40
H-G	2,650	389	5.3	-1.0	50
I-J	3,050	45	6.7	1.0	5
G-J	2,600	617	5.1	-1.0	55
K-L	3,000	17	6.9	3.0	5
L-M	2,900	50	6.7	1.0	5
M-N	3,000	106	6.5	0.0	15
N-O	2,800	187	6.3	-1.0	25
P-V	2,800	41	6.7	1.0	5
V-O	3,000	139	6.4	0.0	15
O-Q	2,700	422	5.5	-2.0	35
R-S	2,600	119	5.8	0.0	15
S-T	2,600	156	5.6	-2.0	20
T-Q	2,600	226	5.5	-2.0	20
Q-U	2,700	539	5.3	-3.0	55
U-J	2,550	577	5.2	-3.0	55

1. See the above titled plate for the reach location.
2. Elevation at the upstream end of the reach.
3. Side slopes 1 on 1.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 57

Canals for Plan D

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet, NGVD)[2]	Bottom Elevation (feet, NGVD)	Bottom Width (feet)[3]
A-B	4,200	30	6.7	1.3	5
B-B1	2,650	89	6.5	-0.8	10
B1-C	2,650	149	6.4	-1.7	15
C-C1	2,600	221	6.3	-2.7	20
C1-C2	2,600	302	6.2	-3.5	25
C2-D	2,600	369	6.1	-4.7	25
D-E	5,200	878	6.2	-5.5	55
E-E1	5,250	516	6.4	-2.1	55
E1-E2	2,625	506	6.5	-2.0	55
E2-F	2,625	502	6.6	-1.9	55
F-G	2,300	500	5.8	-1.9	55
H-I	5,100	35	6.5	0.0	5
I-J	500	77	6.5	-0.4	10
J-K	5,200	155	6.4	-2.6	15
E-K	2,500	257	6.3	-3.0	25

1. See the above titled plate for the reach location.
2. Elevation at the upstream end of the reach.
3. Side slopes 1 on 1.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 58

Canals for Plan F

Summary of Hydraulic Design Data*

Reach Location[1]	Reach Length (feet)	Flow (cfs)	Design Water Surface Elevation (feet, NGVD)[2]	Bottom Elevation (feet, NGVD)	Bottom Width (feet)[3]
A-B	4,910	18	6.61 to 6.72	1.8	5
B-C	5,310	56	6.45 to 6.61	0.3	10
C-D	7,920	124	6.21 to 6.45	-0.7	20
D-E	5,480	197	6.02 to 6.21	-1.7	25
I-J	5,600	14	6.29 to 6.44	2.3	5
J-K	640	30	6.27 to 6.29	0.3	5
K-L	5,320	61	6.10 to 6.27	-0.2	10
L-E	2,620	104	6.02 to 6.10	-1.2	15
E-F	10,300	411	5.30 to 6.02	-2.2	40
F-G	2,400	469	6.70	-2.7	40

1. See the above titled plate for the reach location.
2. Side slopes 1 on 1.
3. 240 feet of reach F-G is concrete lined to limit seepage.

* All elevations are in feet and refer to National Geodetic Vertical Datum.

Table 59

Plan A and B Residential Area Weirs

Summary of Hydraulic Design Data*

Location	D	F	J	O
Design Discharge (cfs)	184	75	12	194
Crest Length (feet)	25	10	5	15
Crest Elevation	4.3	4.4	5.6	3.2
Headwater Elevation	6.3	6.4	6.5	6.1
Tailwater Elevation	5.5	5.3	5.0	5.5
Upstream Channel Invert Elevation	0.5	1.0	4.5	0.5
Downstream Channel Invert Elevation	-0.5	1.0	-1.5	-1.5
Protection Elevation	7.0	7.0	7.0	7.0

Table 60

Plan B Agricultural Area Weir

Summary of Hydraulic Design Data*

Location	J
Design Discharge (cfs)	134
Crest Length (feet)	20
Crest Elevation	4.0
Headwater Elevation	5.9
Tailwater Elevation	5.4
Upstream Channel Invert Elevation	0.8
Downstream Channel Invert Elevation	-0.8
Protection Elevation	7.0

Table 61

Plan C Weirs

Summary of Hydraulic Design Data*

Location	D	F	J	O
Design Discharge (cfs)	324	195	89	422
Crest Length	52	27	11	49
Crest Elevation	4.5	4.5	4.5	3.8
Headwater Elevation	6.3	6.4	6.5	6.1
Tailwater Elevation	5.5	5.4	5.0	5.5
Upstream Channel Invert	-1.0	1.0	1.0	-1.0
Downstream Channel Invert	-1.0	-1.0	-3.0	-2.0
Protection Elevation	7.0	7.0	7.0	7.0

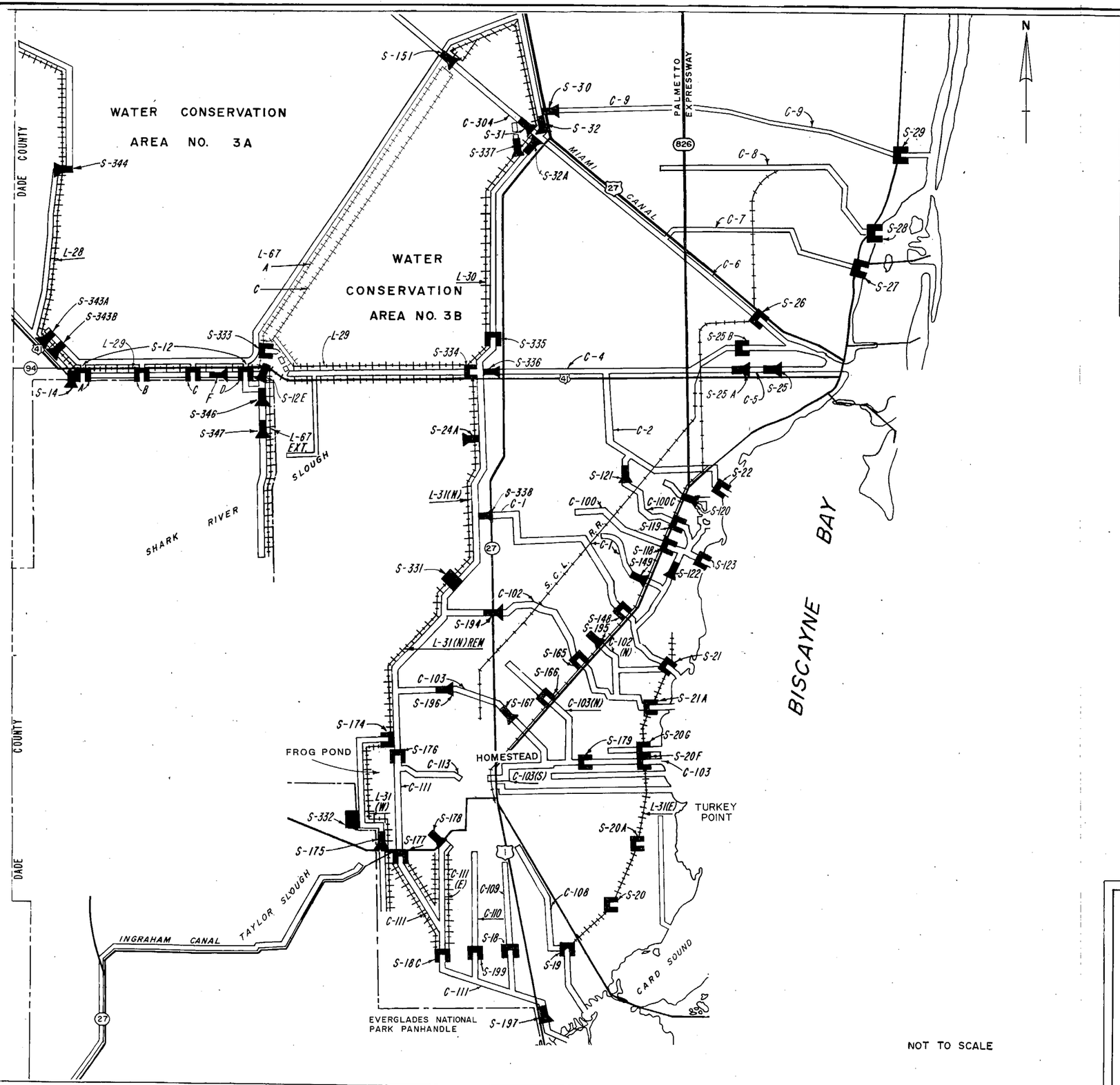
* All elevations are in feet and refer to National Geodetic Vertical Datum.

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

PART I

AGRICULTURAL AND CONSERVATION AREAS
SUPPLEMENT 54 - GENERAL DESIGN MEMORANDUM
MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

PLATES

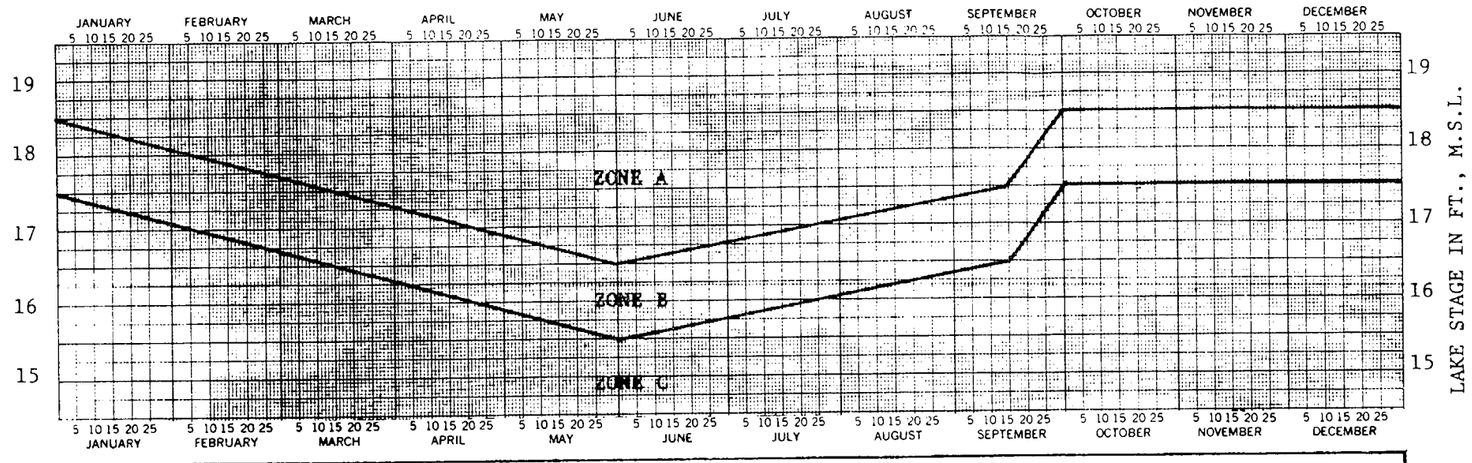


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

LOCATION MAP

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



RELEASE THROUGH OUTLETS AS INDICATED			
ZONE	AGRICULTURAL CANALS	CALOOSAHATCHEE RIVER	ST. LUCIE CANAL
A	PUMP MAXIMUM PRACTICABLE TO CONSERVATION AREAS FOR REGULATION AFTER REMOVAL OF LOCAL RUNOFF.	UP TO MAXIMUM CAPACITY (9,300 C.F.S. AT S-77) WITHOUT LOCAL FLOODING	UP TO MAXIMUM DISCHARGE AT S-308C
B*		UP TO 4500 C.F.S. AT S-77	UP TO 2,500 C.F.S. AT S-80**
C	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE
	FIRST PRIORITY	SECOND PRIORITY	THIRD PRIORITY

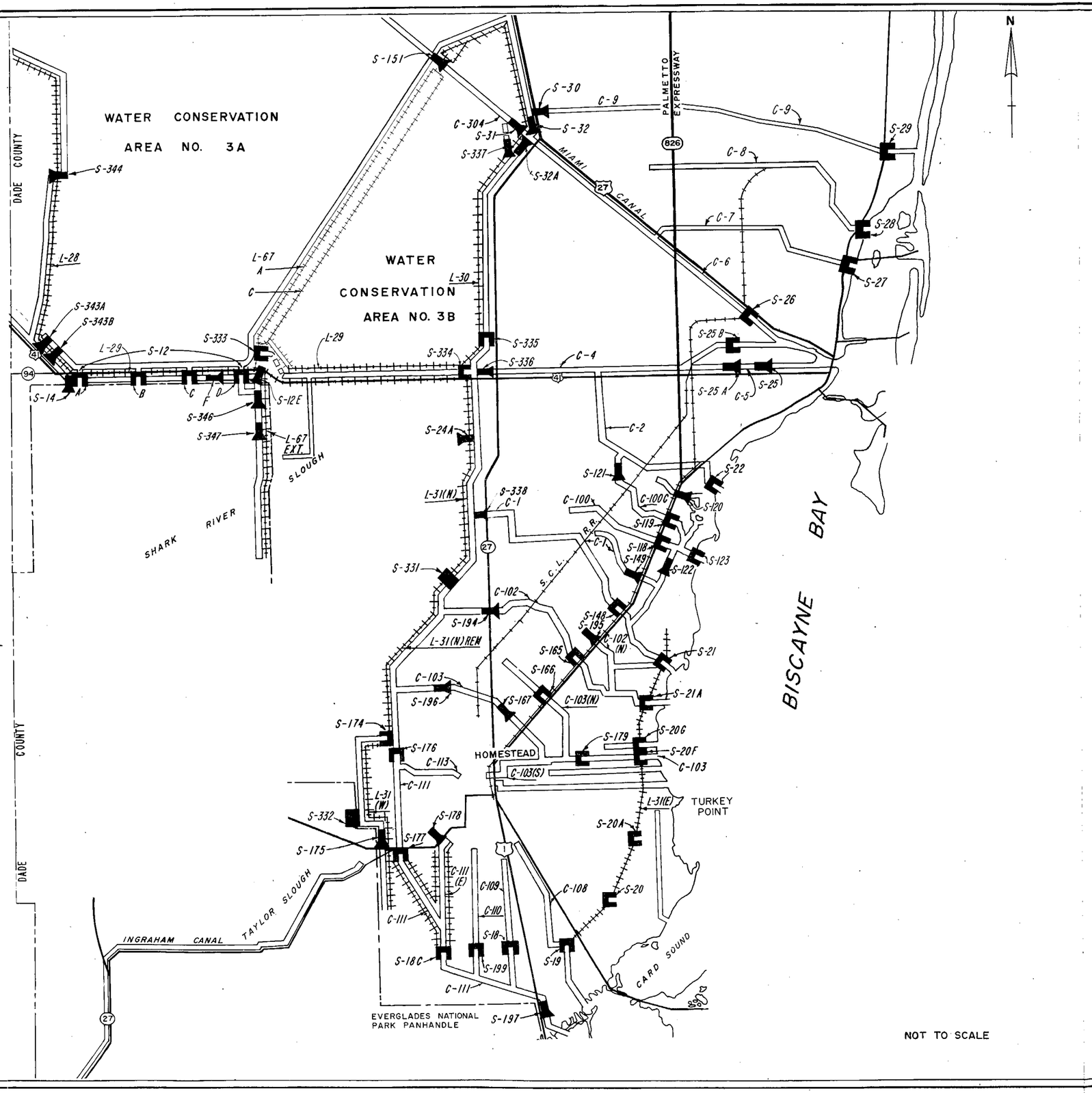
*RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS

**EXCEPT WHEN EXCEEDED BY LOCAL INFLOW

Central and Southern Florida
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
DATED 10 May 1978

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA
LAKE OKEECHOBEE
INTERIM REGULATION SCHEDULE
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART I, SUPPLEMENT 54, DATED: MARCH 1980
D.O. FILE NO. 460-35,002

PLATE 2

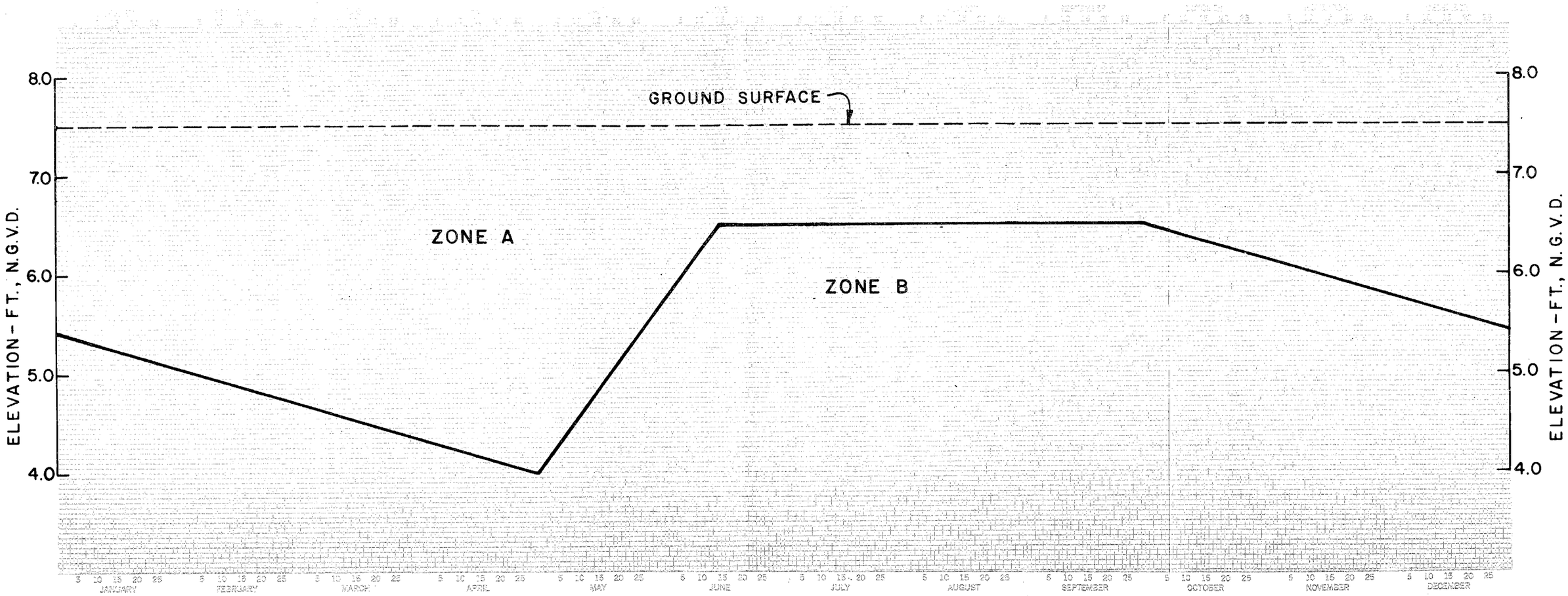


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

BASIC PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662

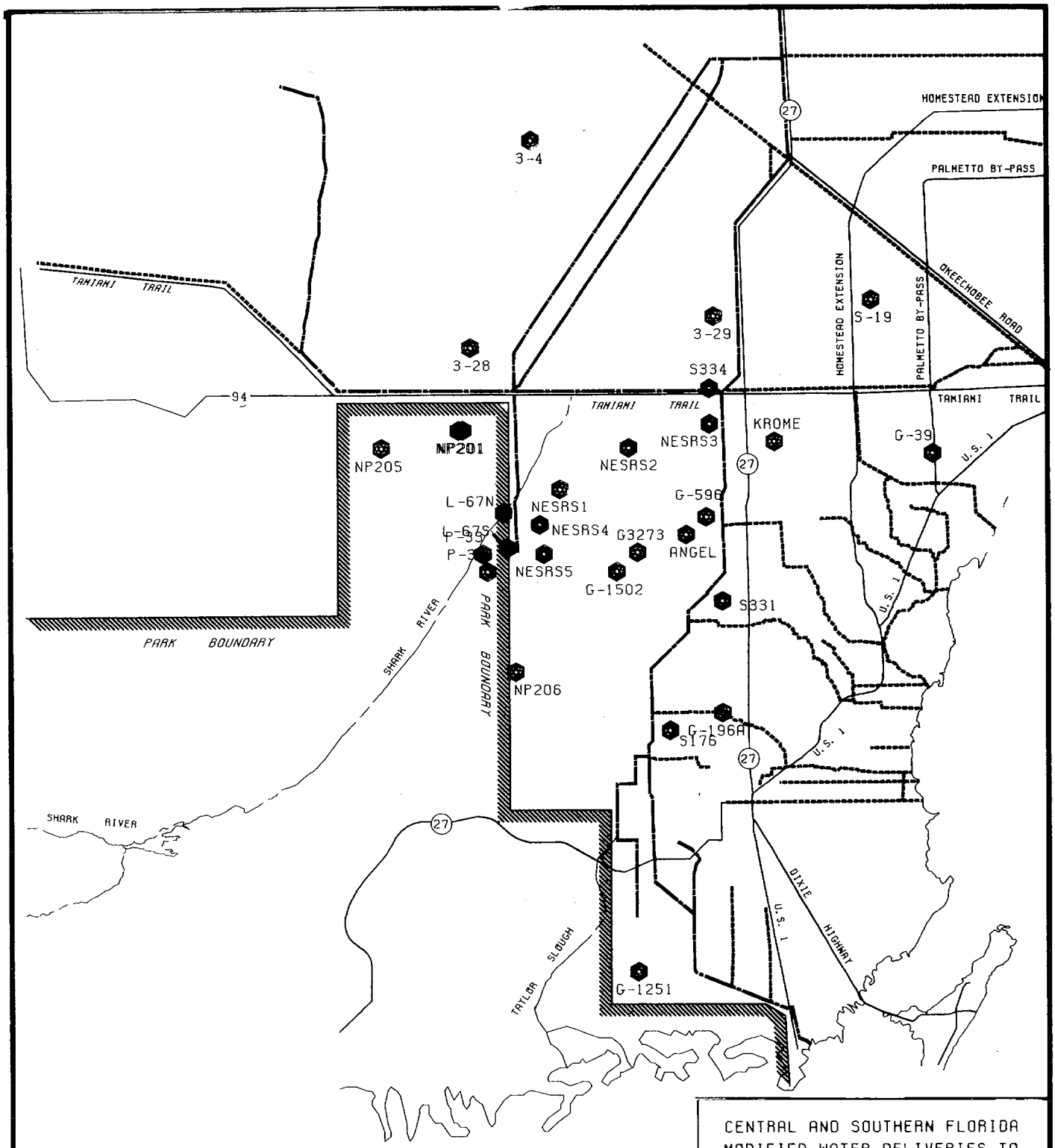


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

G - 596

REGULATION SCHEDULE

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART I, SUPPLEMENT 54, DATED: MARCH 1990
D.O. FILE NO. 400-35, 652



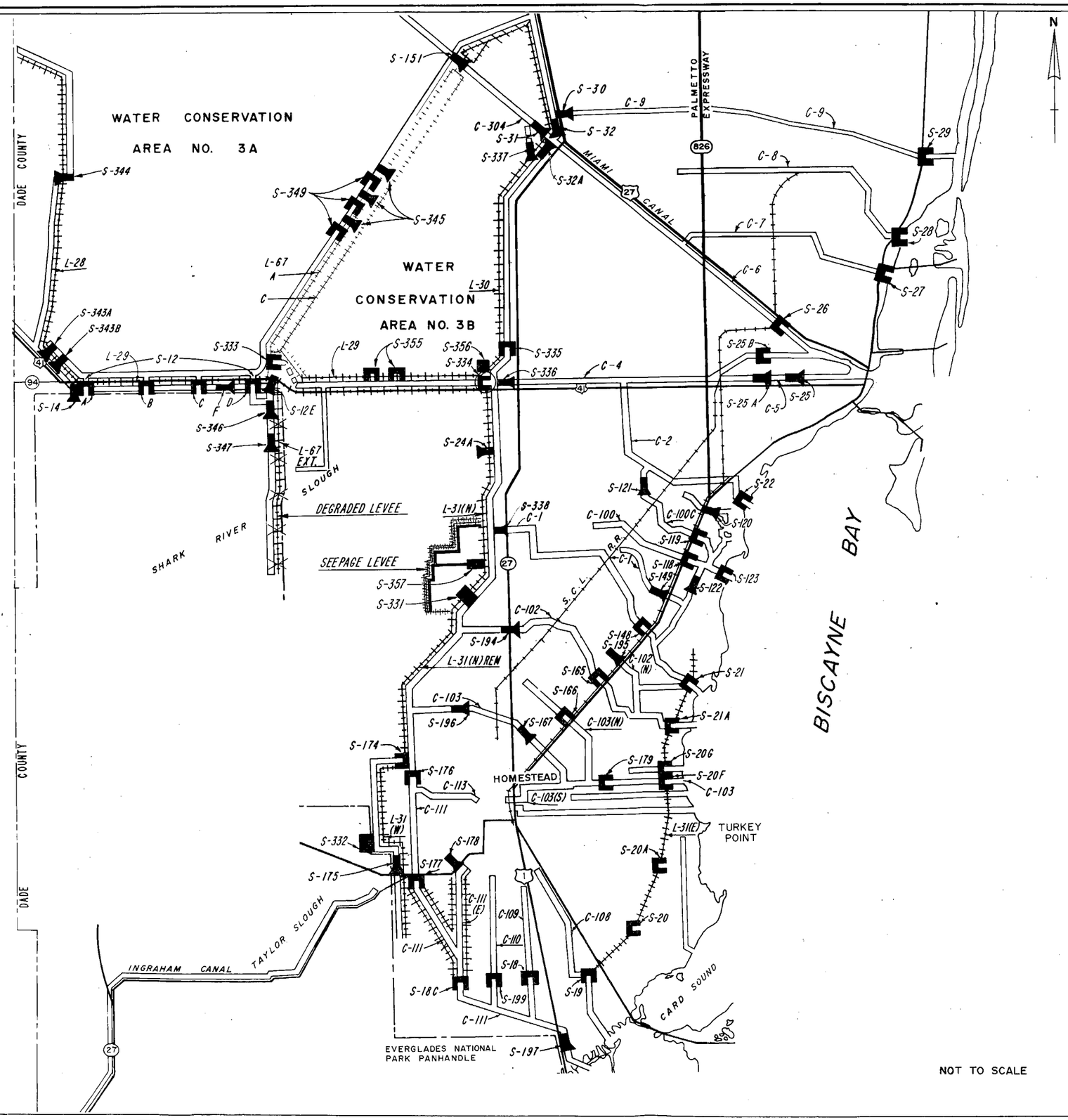
LEGEND

- GAGE
- CANAL
- LEVEE AND CANAL

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK,
FLORIDA

GAGE LOCATIONS

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART 1, SUPPLEMENT 54 DATED MARCH 1990
FILE NO. 400-35,662



LEGEND

PROPOSED

- CANAL
- LEVEE
- PUMPING STATION
- CULVERT
- SPILLWAY
- SPILLWAY TO BE MODIFIED

EXISTING

- CANAL
- LEVEE
- SPILLWAY
- PUMPING STATION
- CULVERTS

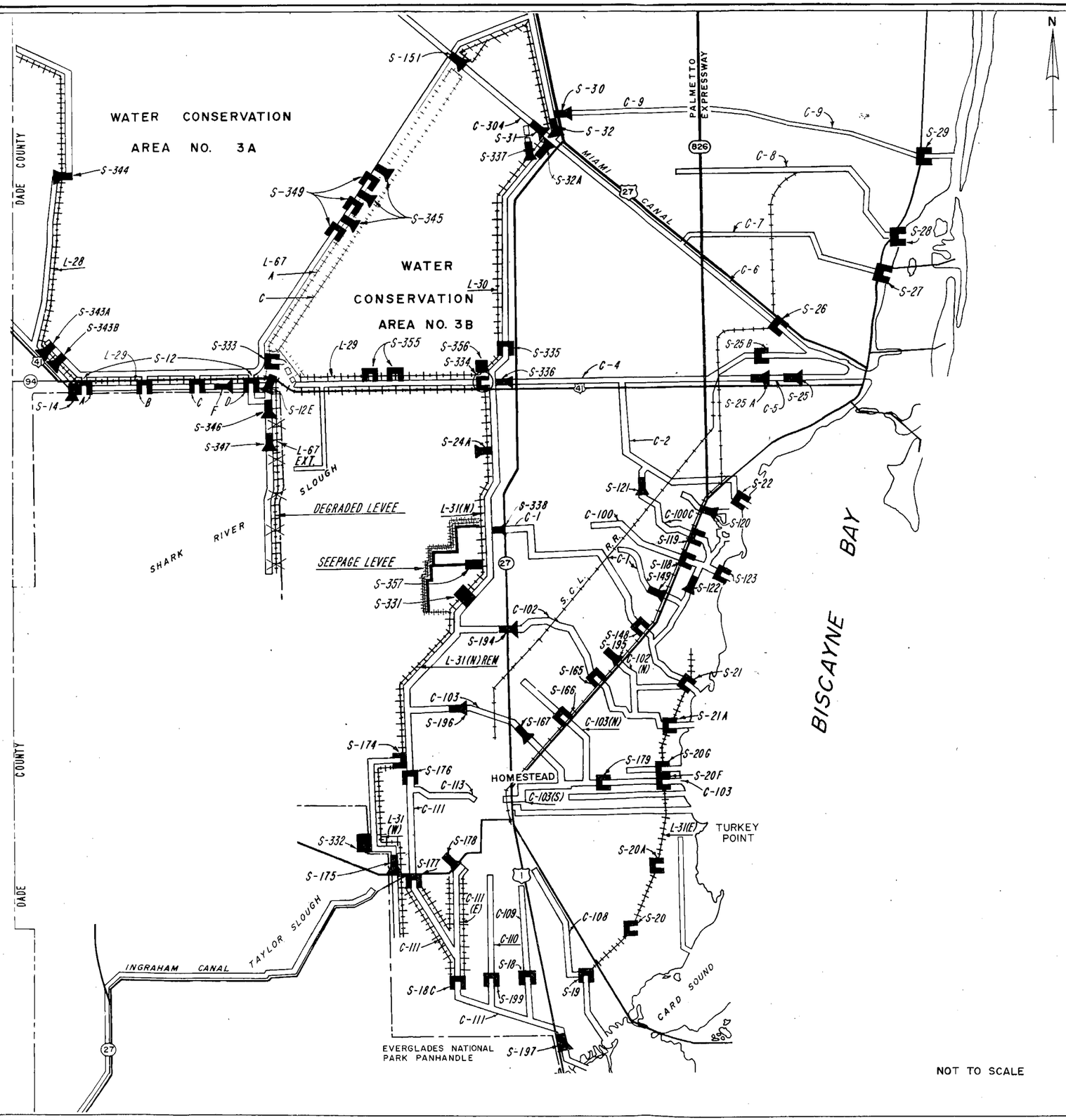
NOT TO SCALE

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

BASIC RAIN DRIVEN PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



LEGEND

PROPOSED

- CANAL
- LEVEE
- PUMPING STATION
- CULVERT
- SPILLWAY
- SPILLWAY TO BE MODIFIED

EXISTING

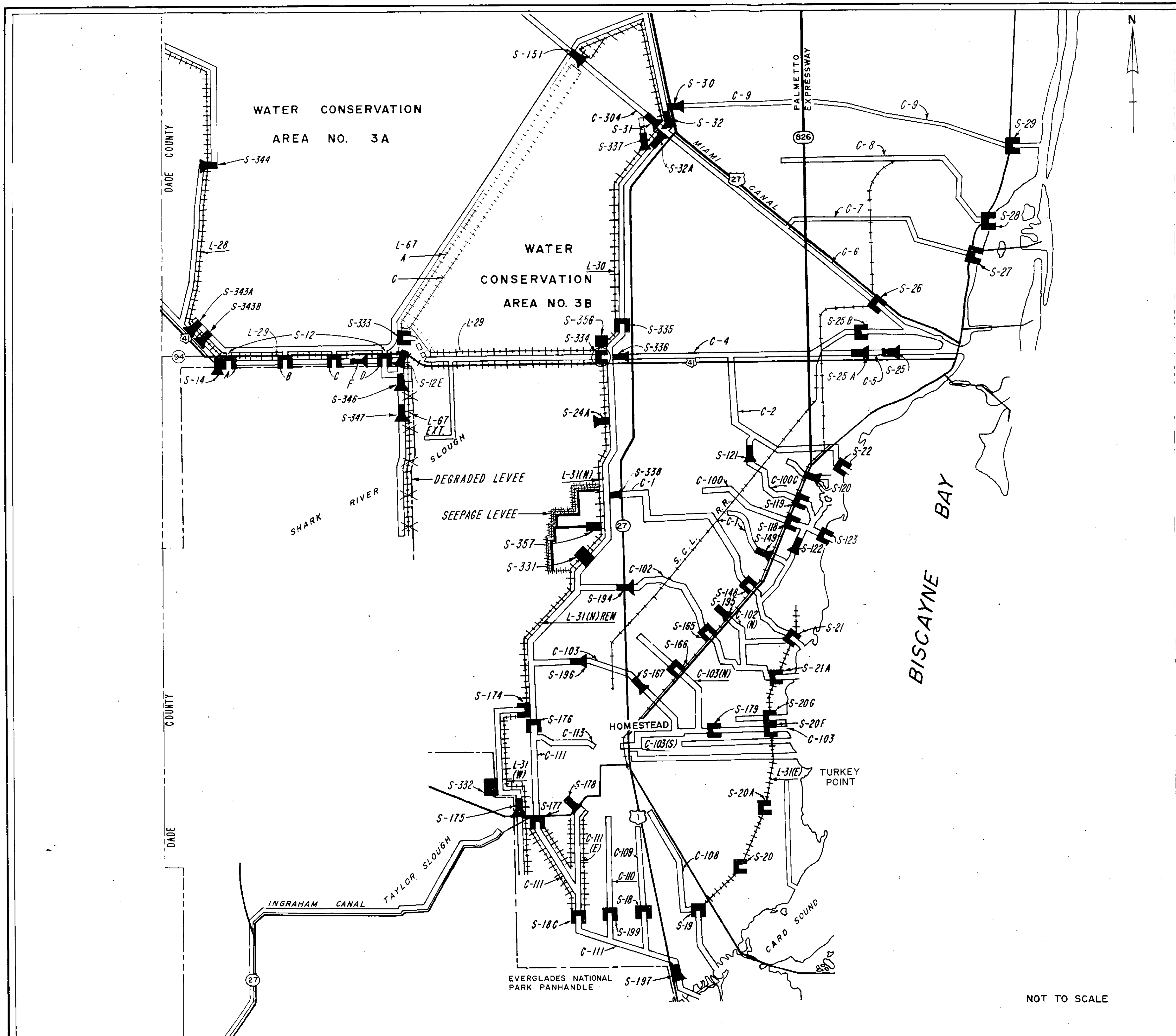
- CANAL
- LEVEE
- SPILLWAY
- PUMPING STATION
- CULVERTS

NOT TO SCALE

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

MODIFIED RAIN DRIVEN PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



LEGEND

PROPOSED

- CANAL
- LEVEE
- PUMPING STATION
- CULVERT
- SPILLWAY
- SPILLWAY TO BE MODIFIED

EXISTING

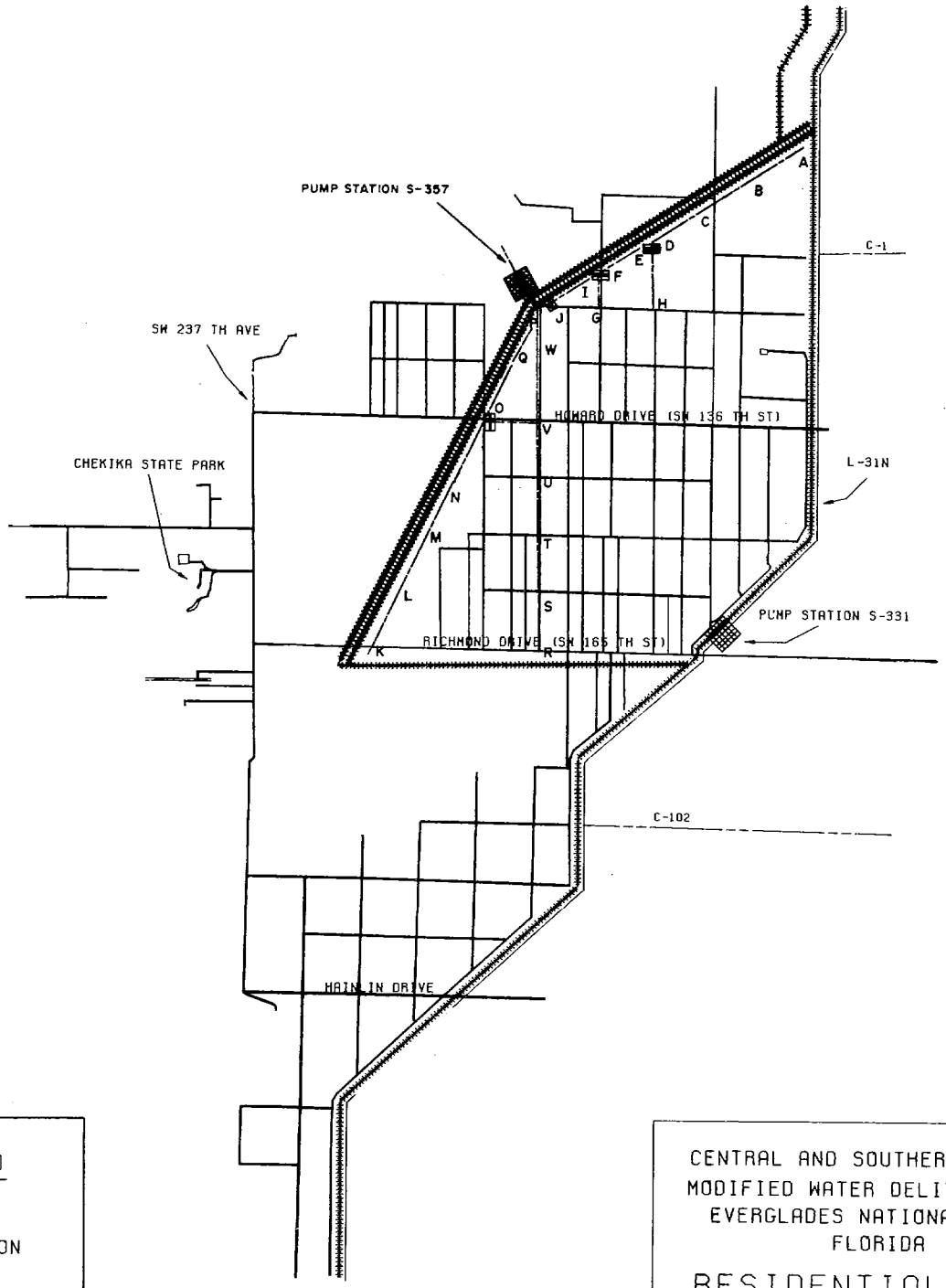
- CANAL
- LEVEE
- SPILLWAY
- PUMPING STATION
- CULVERTS

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

MODIFIED MINIMUM DELIVERY PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662

PLATE 8



LEGEND

- PUMP STATION
- WEIR
- CULVERT
- CANAL
- LEVEE

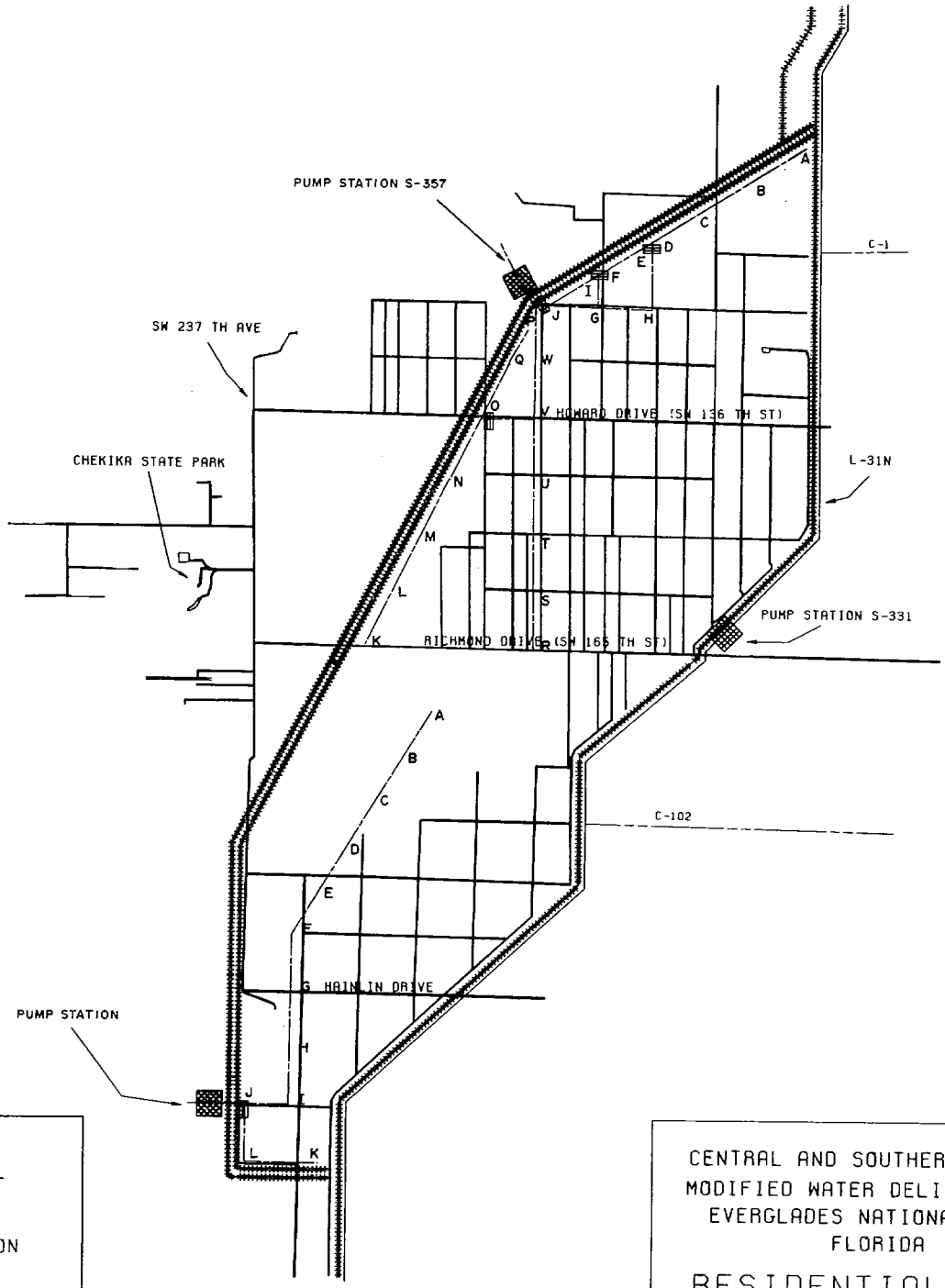
NOTE: ALL ITEMS IN RED ARE PROPOSED ADDITIONS TO THE PROJECT.

CENTRAL AND SOUTHERN FLORIDA MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA

PLAN A

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART 1, SUPPLEMENT 54 DATED MARCH 1990
FILE NO. 400-35,662



LEGEND

- PUMP STATION
- WEIR
- CULVERT
- CANAL
- LEVEE

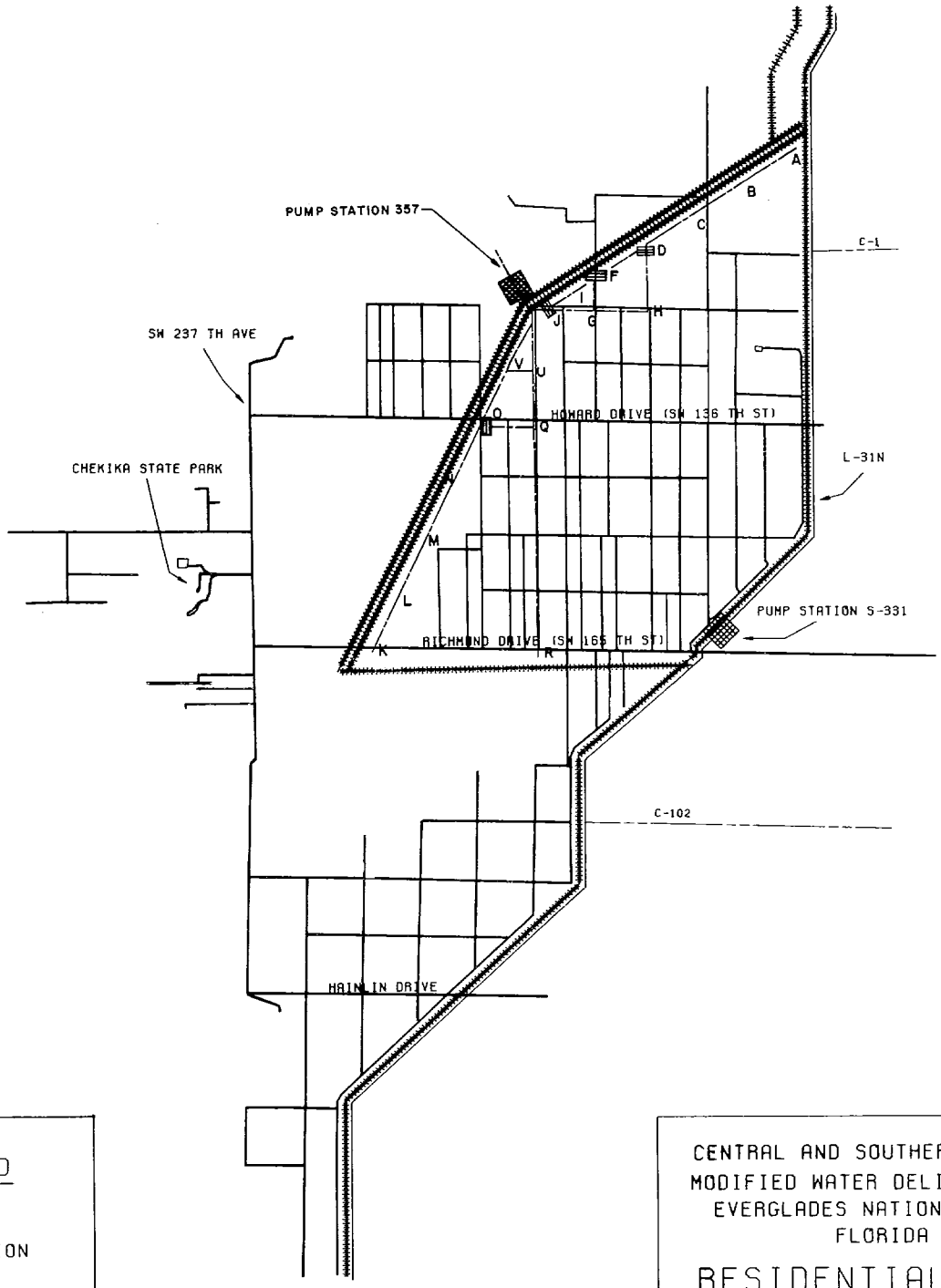
NOTE: ALL ITEMS IN RED ARE PROPOSED ADDITIONS TO THE PROJECT.

CENTRAL AND SOUTHERN FLORIDA MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA

PLAN B

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM PART I, SUPPLEMENT 54 DATED MARCH 1990
FILE NO. 400-35,662



LEGEND

- PUMP STATION
- WEIR
- CULVERT
- --- CANAL
- LEVEE

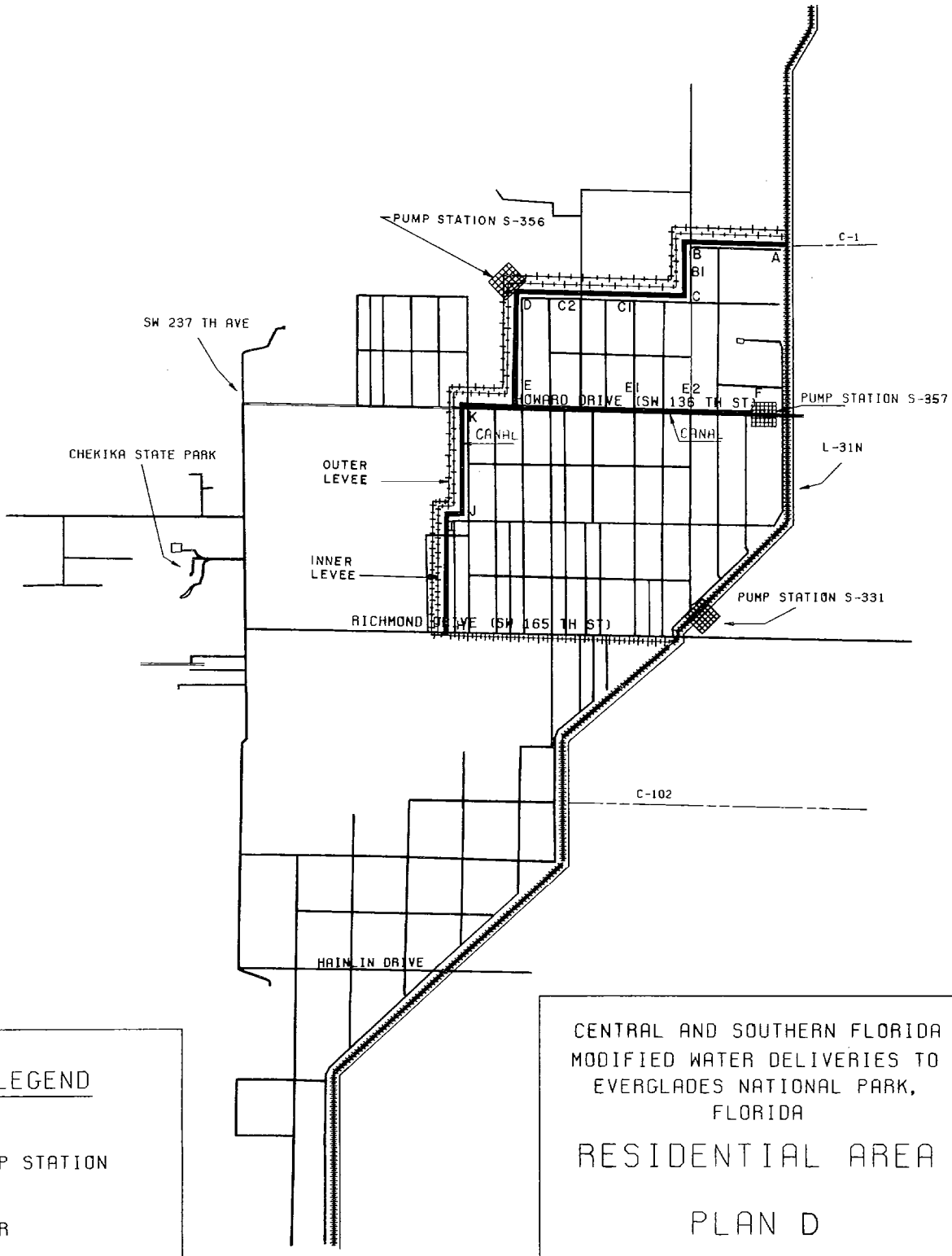
NOTE: ALL ITEMS IN RED ARE PROPOSED ADDITIONS TO THE PROJECT.

CENTRAL AND SOUTHERN FLORIDA MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA

PLAN C

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART I, SUPPLEMENT 54 DATED MARCH 1990
FILE NO. 400-35,662



LEGEND

- PUMP STATION
- WEIR
- CULVERT
- CANAL
- LEVEE

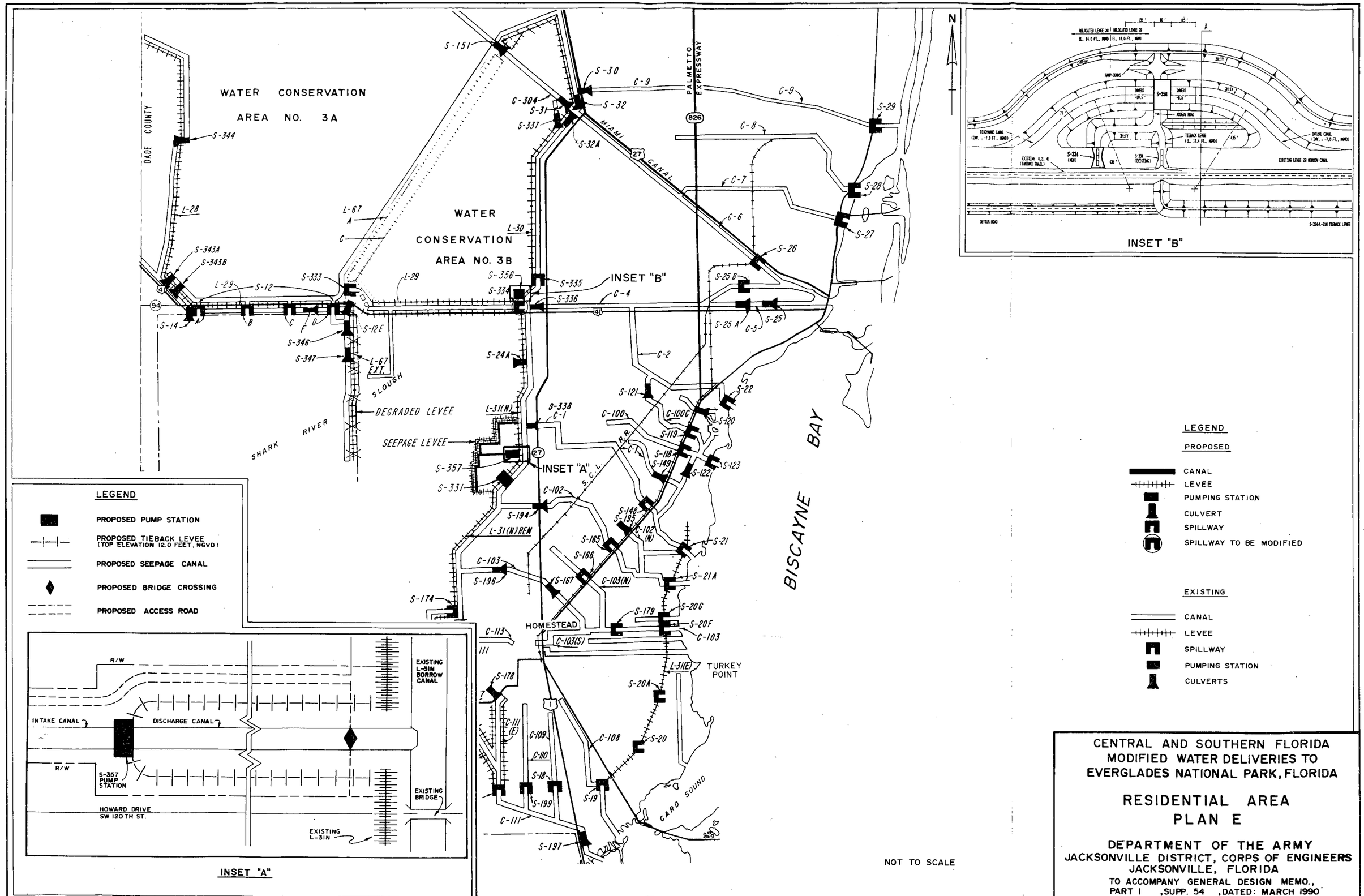
NOTE: ALL ITEMS IN RED ARE PROPOSED ADDITIONS TO THE PROJECT.

CENTRAL AND SOUTHERN FLORIDA MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA

PLAN D

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM PART I, SUPPLEMENT 54 DATED MARCH 1990
FILE NO. 400-35.662

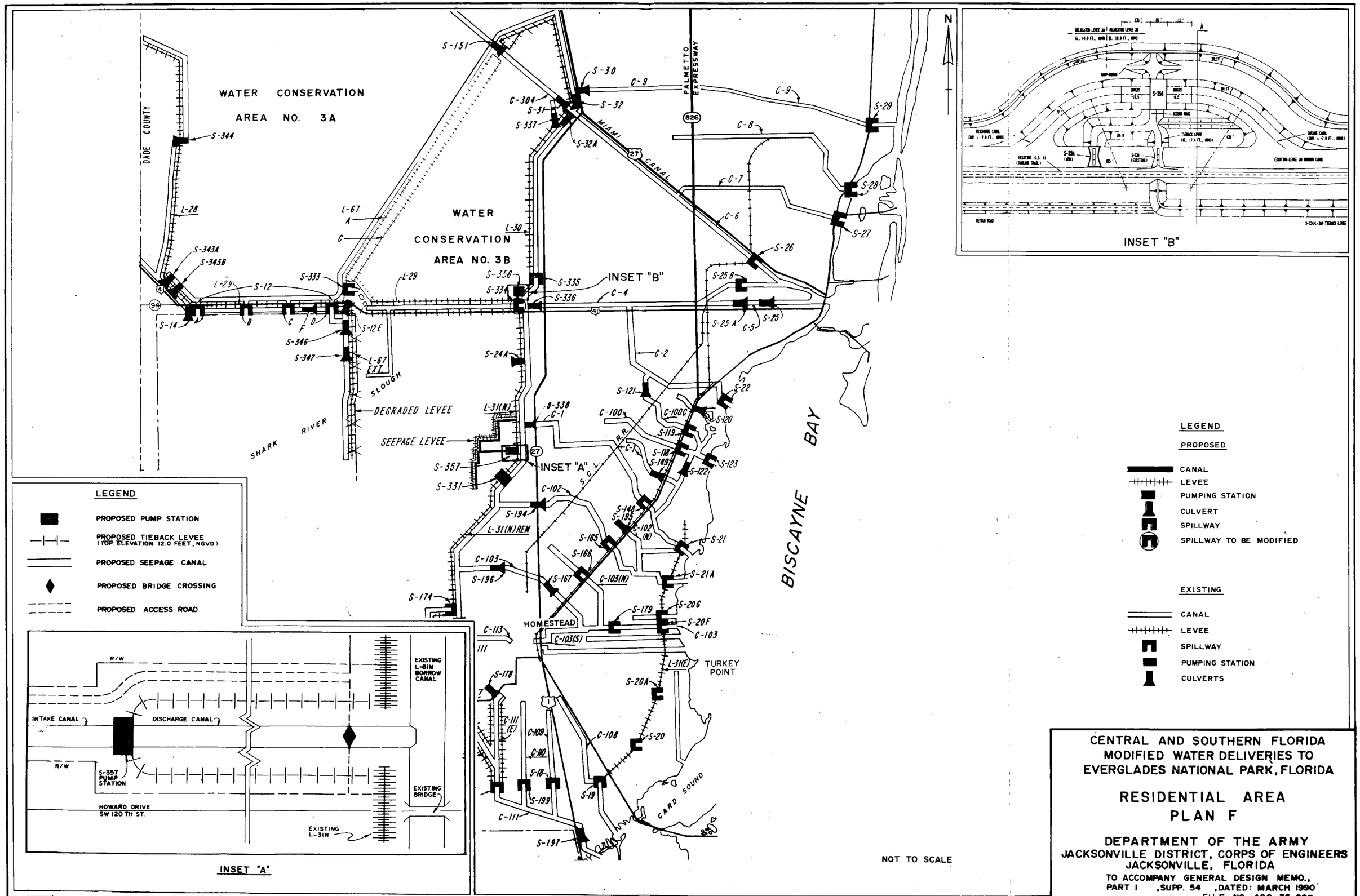


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA
PLAN E

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

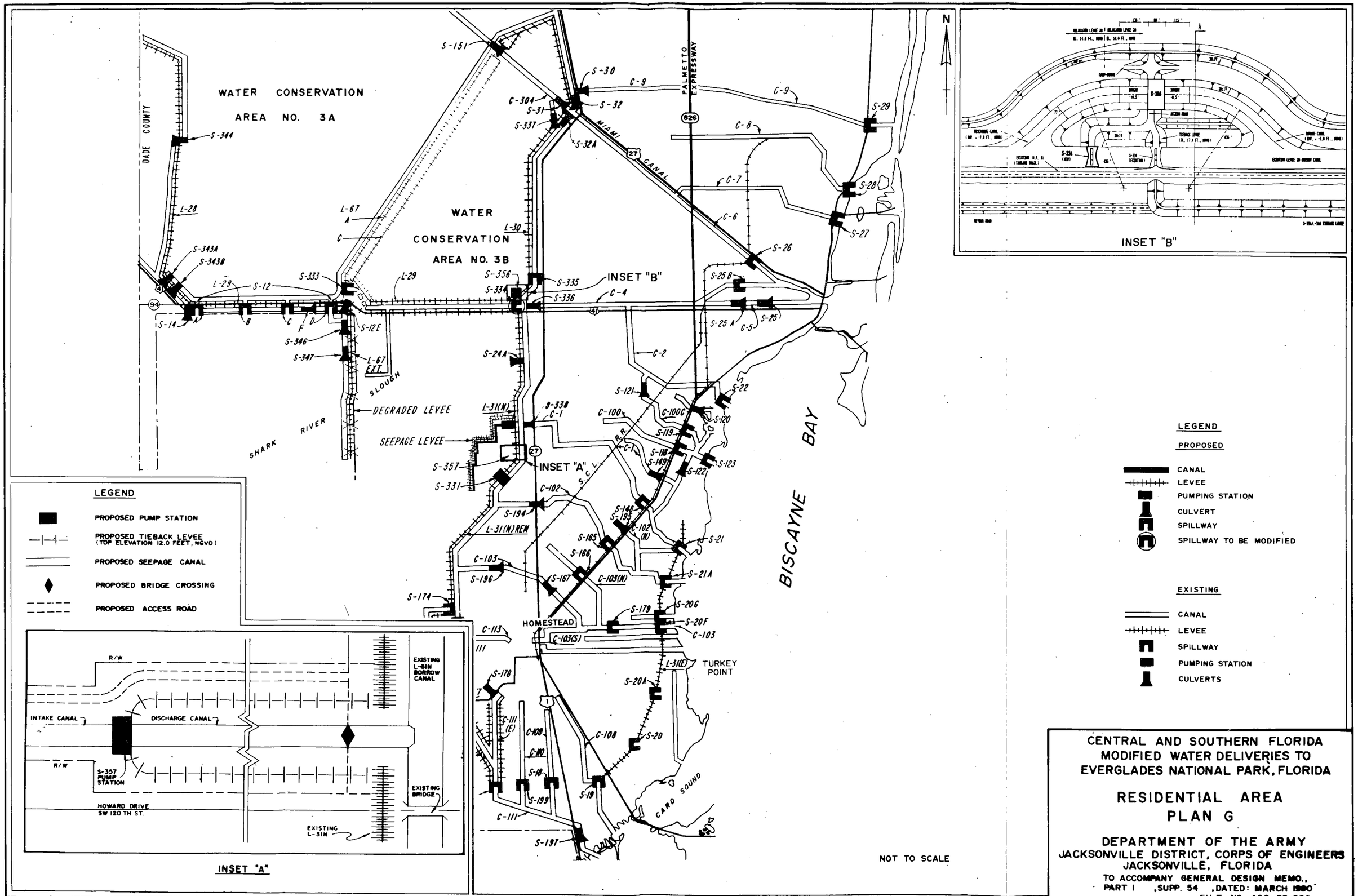
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA
PLAN F

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662

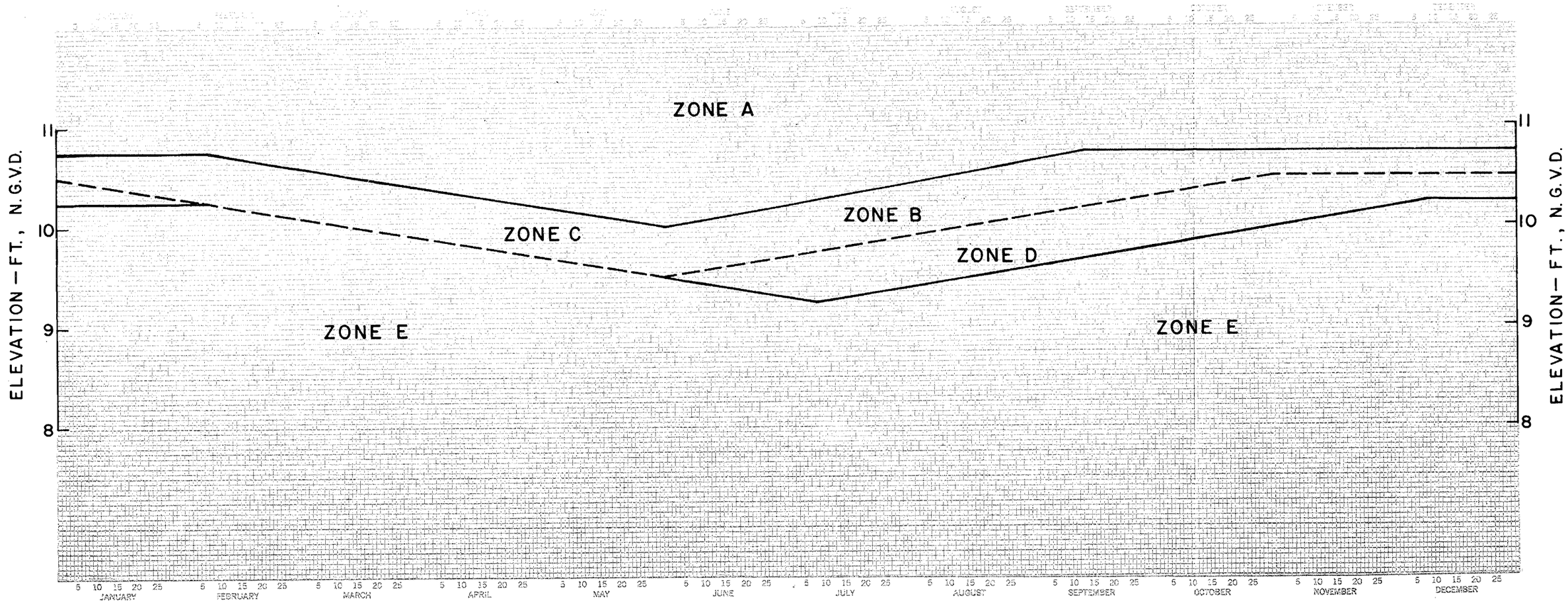


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

RESIDENTIAL AREA
PLAN G

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1980
FILE NO. 400-35,662

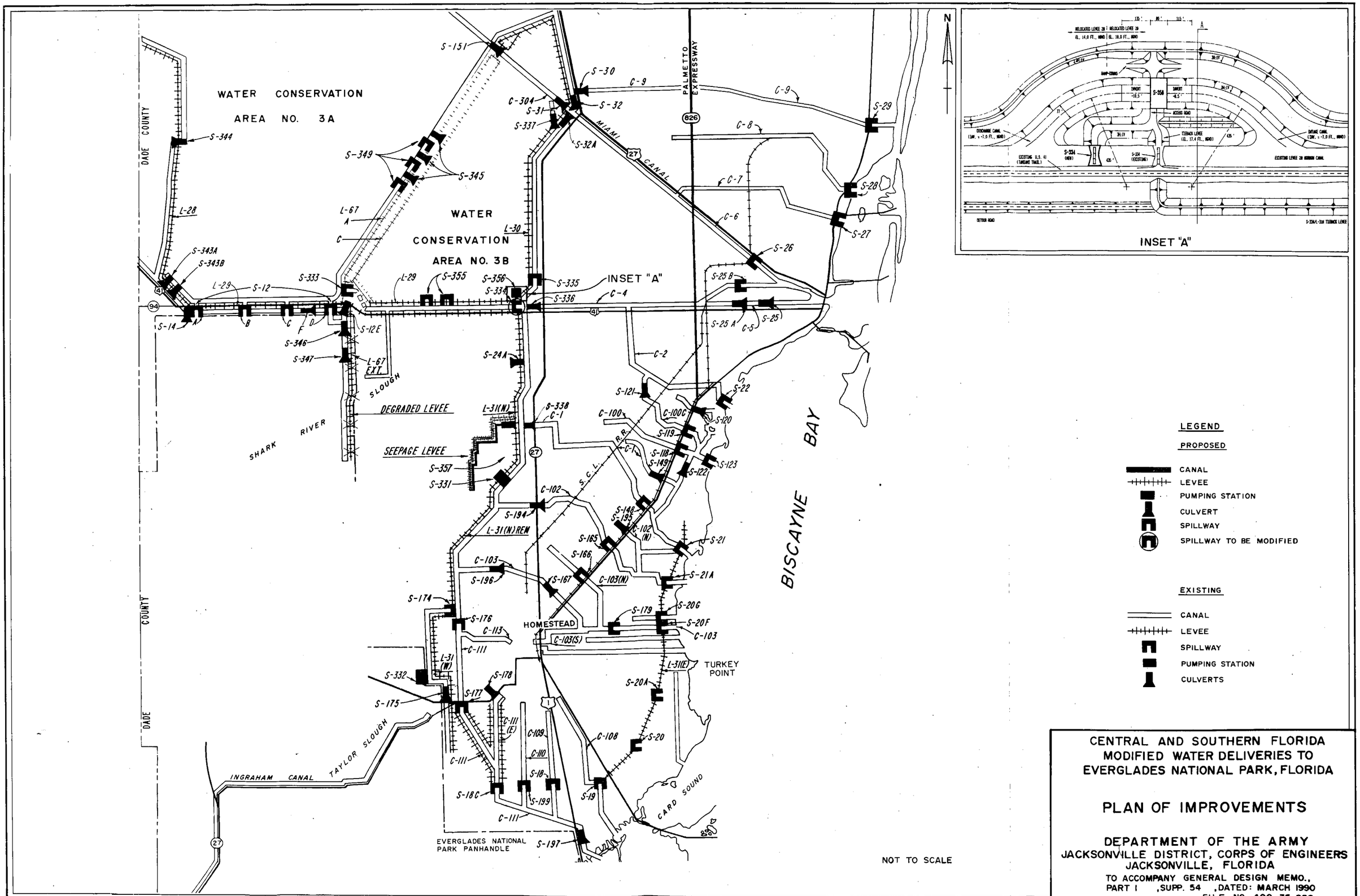


CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

WATER CONSERVATION

AREA NO. 3A

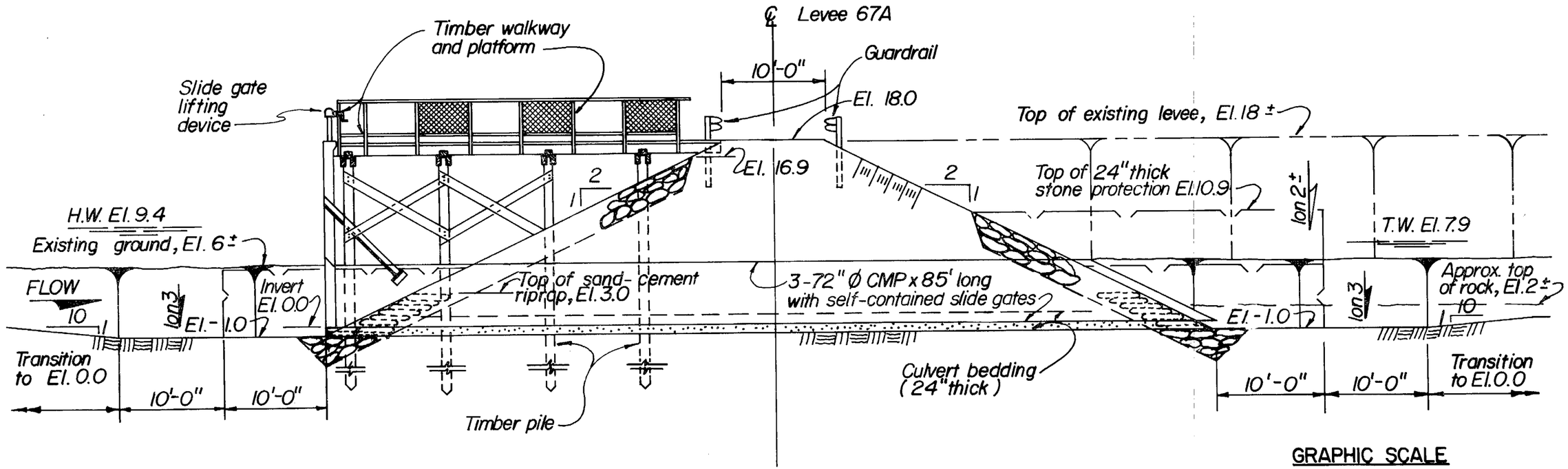
REGULATION SCHEDULE
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMORANDUM
PART I, SUPPLEMENT 54, DATED: MARCH 1990
D.O. FILE NO. 400-36.062



CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

PLAN OF IMPROVEMENTS

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



GRAPHIC SCALE

"A" 10' 0 10' 20'

TYPICAL SECTION

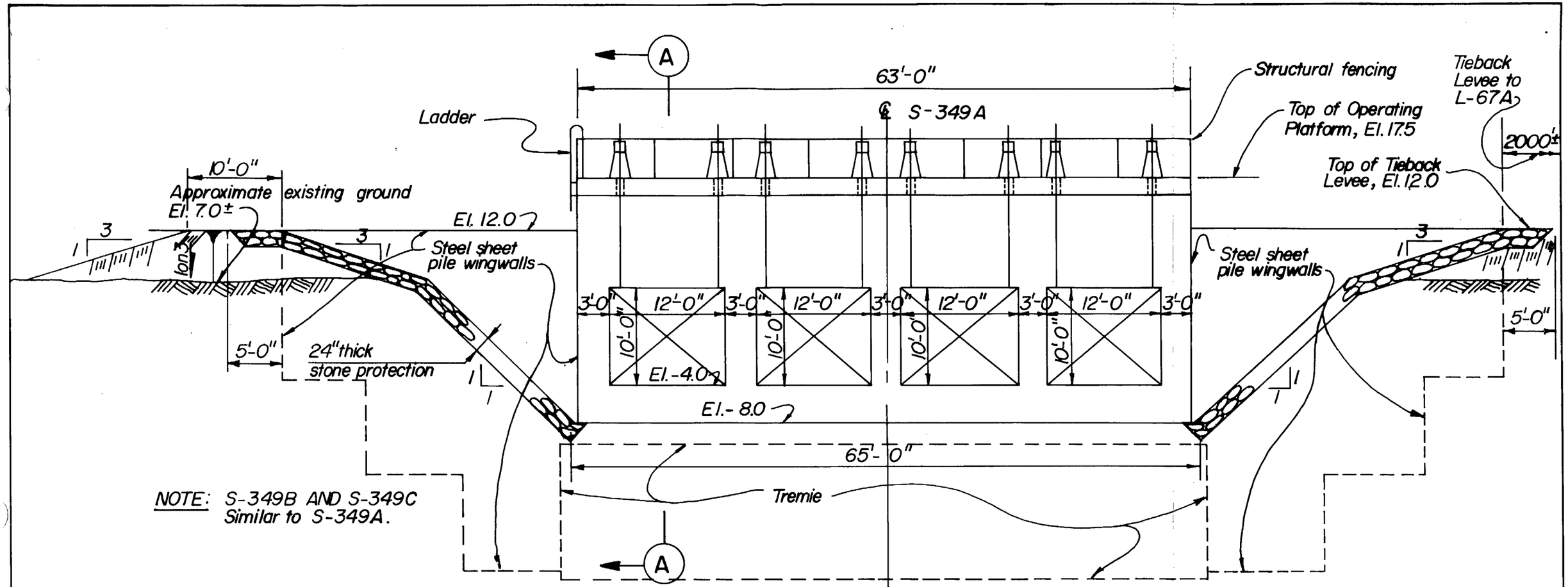
CULVERTS S-345A, S-345 B, & S-345C

SCALE: "A"

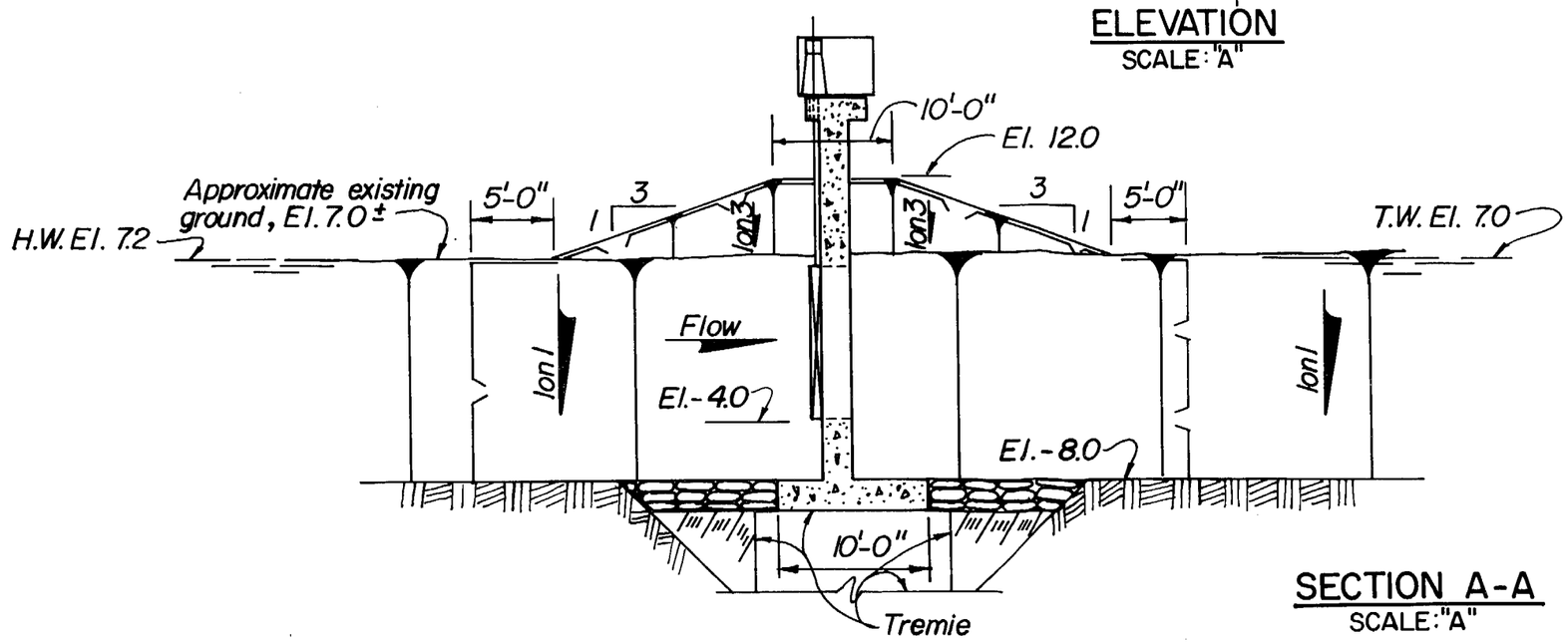
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA
S-345A, B & C
SECTION
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY DETAIL DESIGN MEMO.,
PART I, SUPP. 54, DATED. MAR. 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991

PLATE 18



ELEVATION
SCALE: "A"



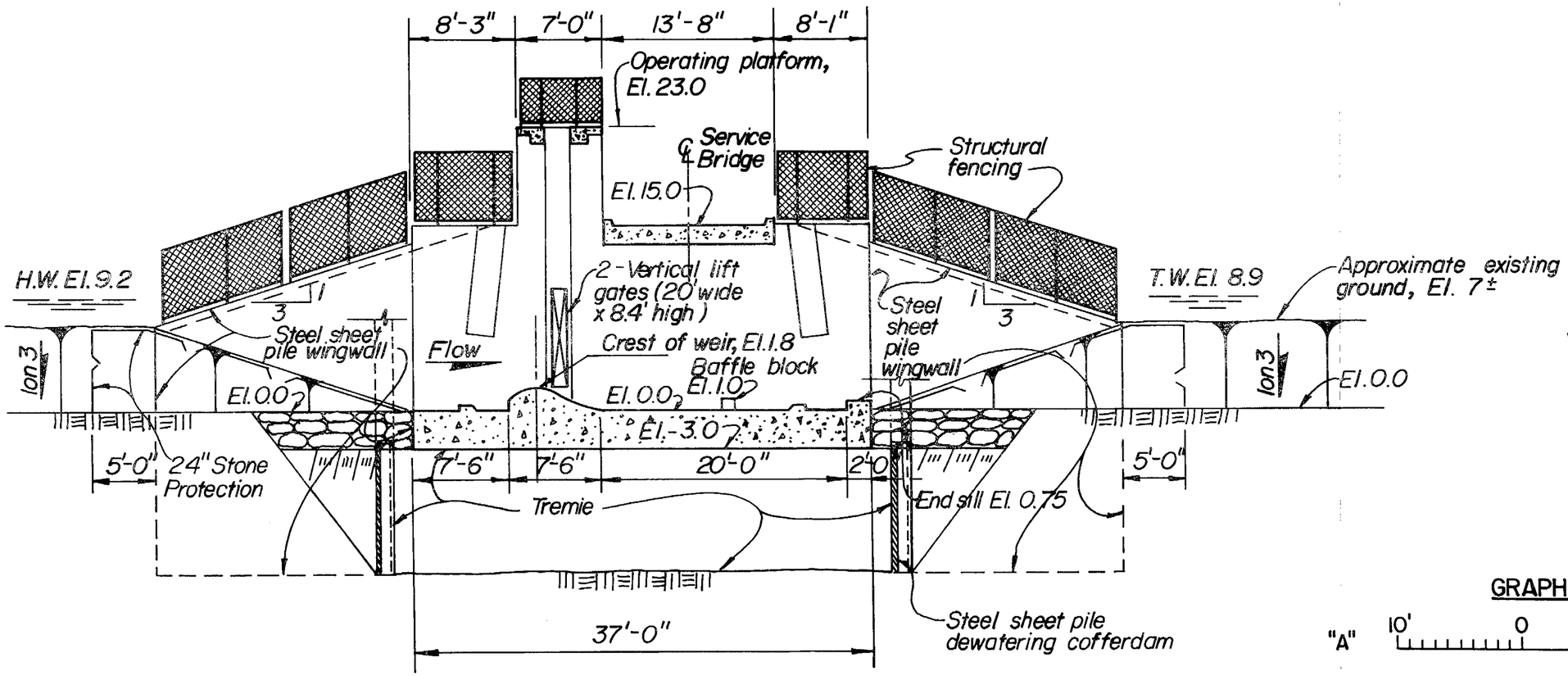
SECTION A-A
SCALE: "A"

GRAPHIC SCALE

"A" 10' 0 10' 20'

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA
S-349A, B & C
SECTION AND ELEVATION
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY DETAIL DESIGN MEMO., PART I, SUPP. 54, DATED. MAR. 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991 PLATE 19



TYPICAL SECTION

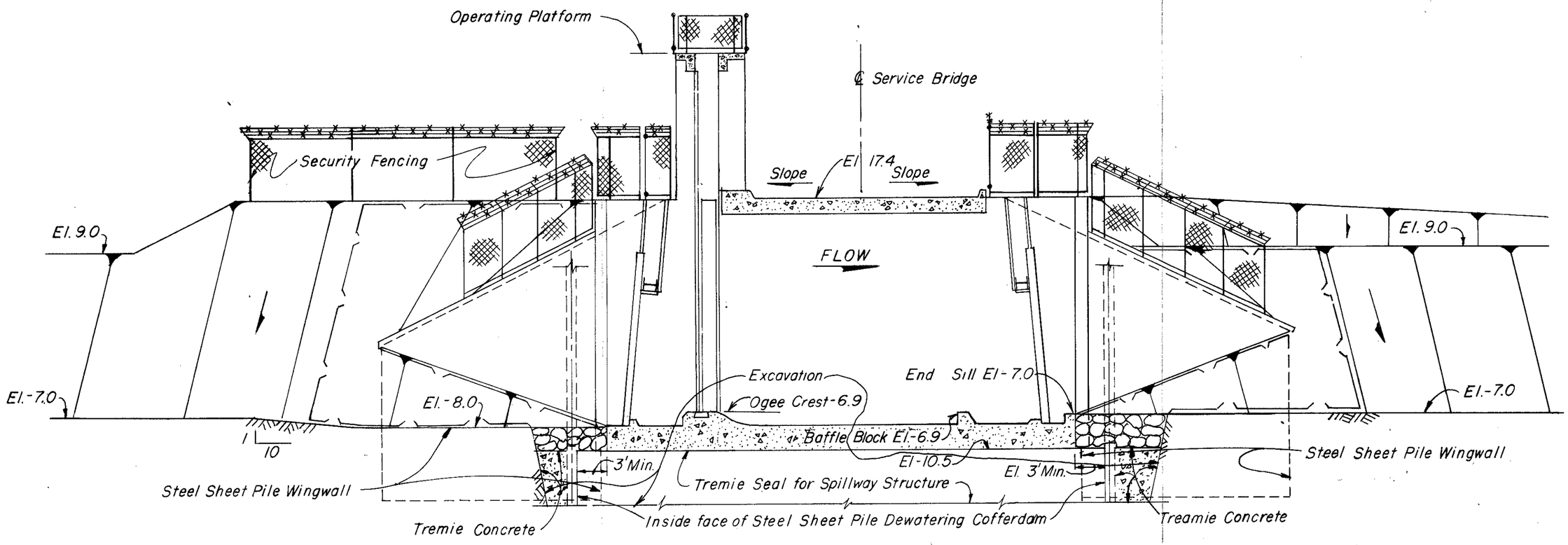
SPILLWALLS S-355A & S-355B

SCALE: A

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA
S-355 A & B
SECTION
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY DETAIL DESIGN MEMO.,
PART I, SUPP. 54, DATED. MAR. 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991

PLATE 20

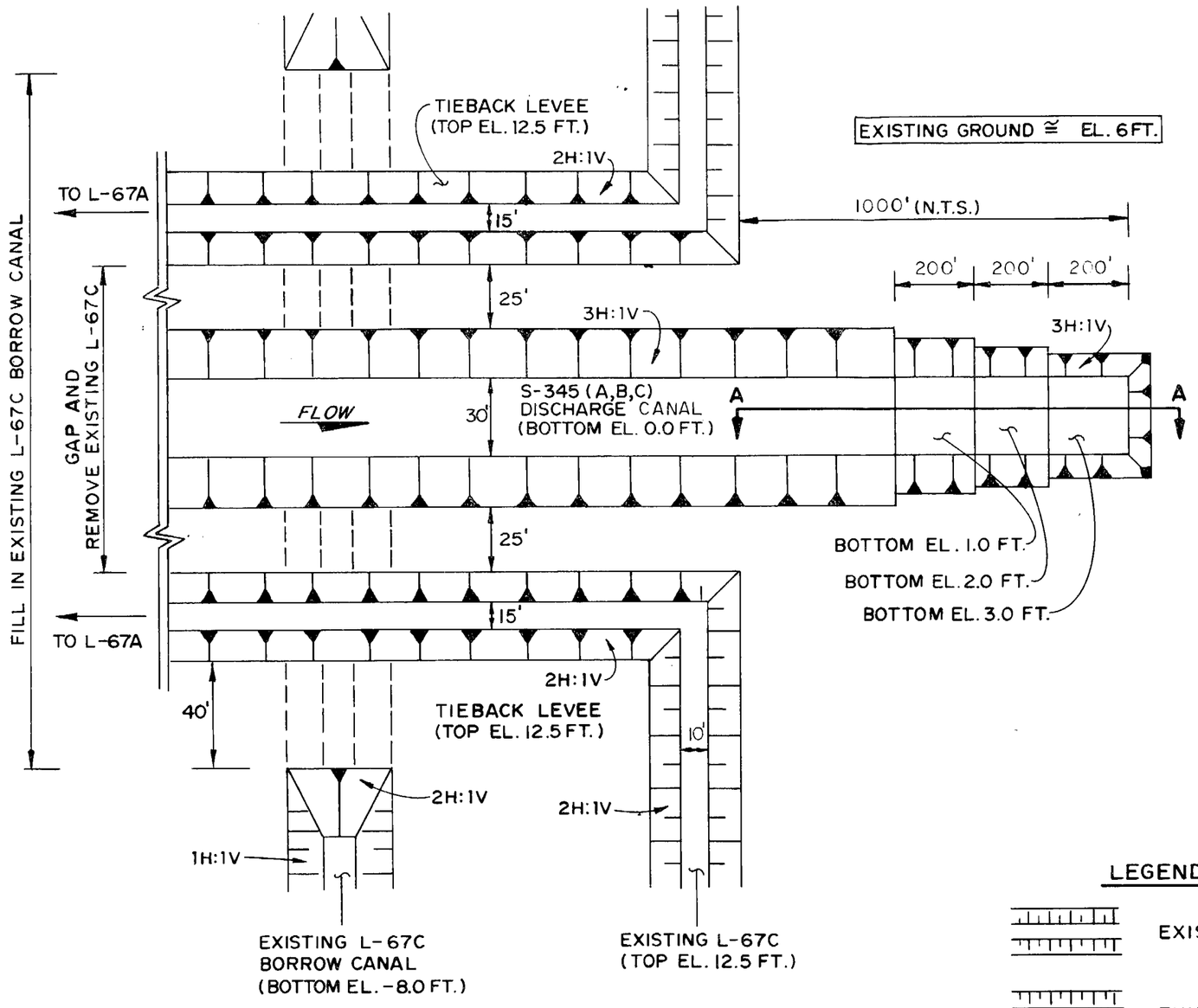


TYPICAL SECTION
NEW SPILLWAY S-334

NOT TO SCALE

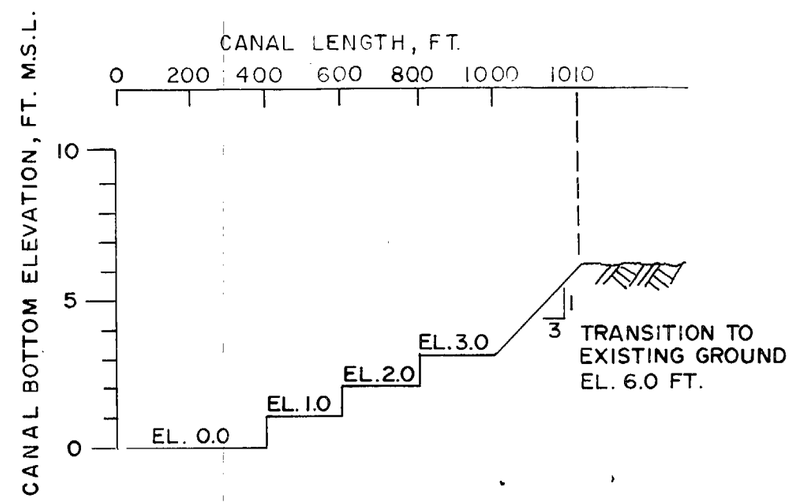
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES
TO EVERGLADES NATIONAL PARK, FLORIDA
NEW SPILLWAY S-334
SECTION
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY DETAIL DESIGN MEMO.,
PART I, SUPP. 54, DATED. MAR. 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991 PLATE 21



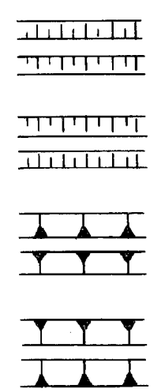
TYPICAL PLAN, VICINITY JUNCTION OF STRUCTURE 345 (A,B,C) DISCHARGE CANAL WITH LEVEE 67C

SCALE: "A" (EXCEPT AS NOTED)

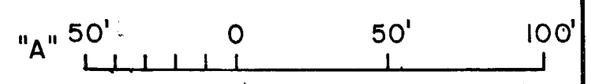


SECTION A-A

LEGEND

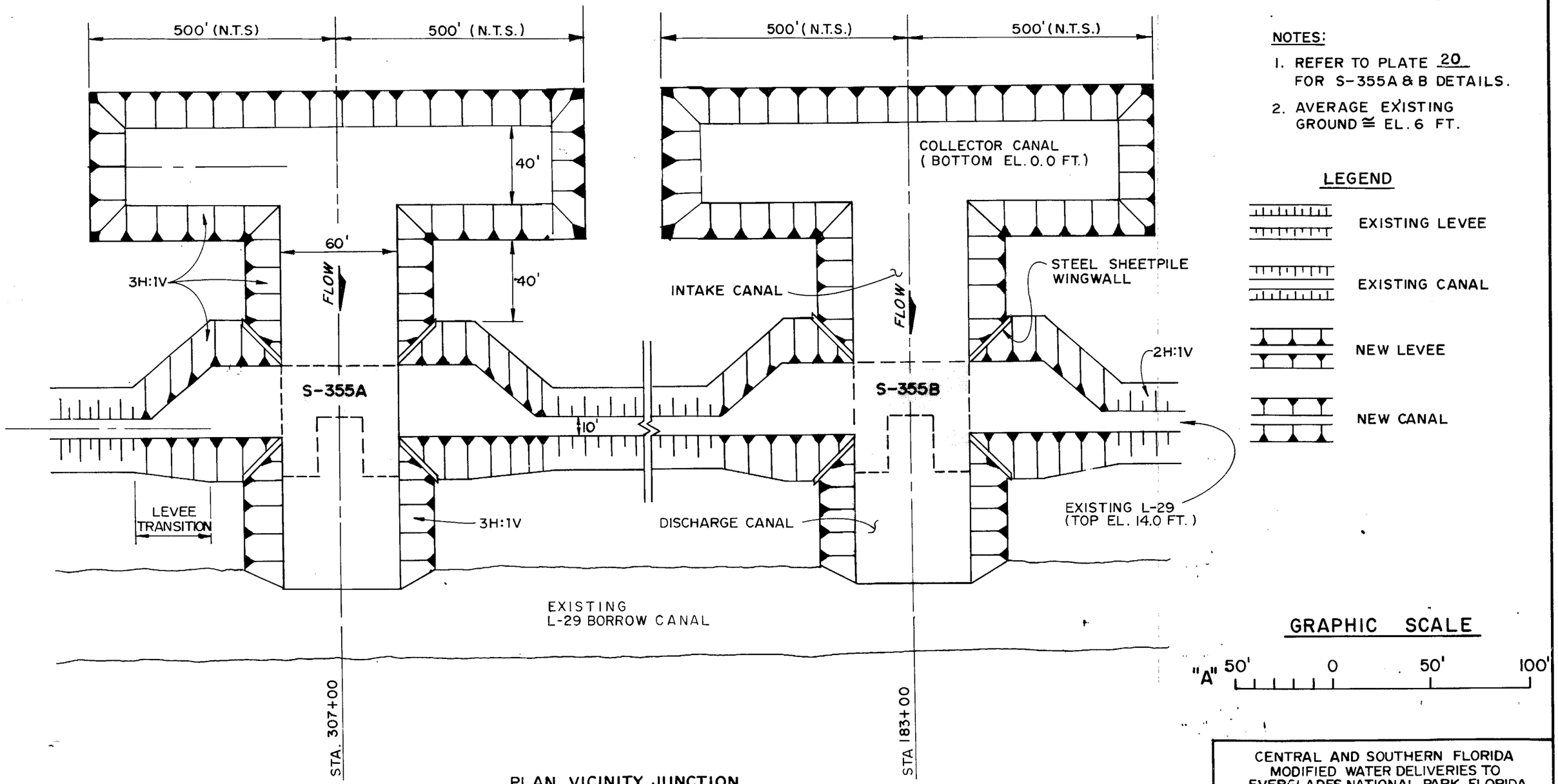


GRAPHIC SCALE



CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA
STRUCTURE 345 (A,B,C)
DISCHARGE CANAL
GENERAL PLAN AND SECTION
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I , SUPP. 54 , DATED: MARCH 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991



PLAN, VICINITY JUNCTION
OF SPILLWAYS S-355A &
S-355B WITH L-29

SCALE : "A" (EXCEPT AS NOTED)

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

STRUCTURES 355A & 355B,
GENERAL PLAN

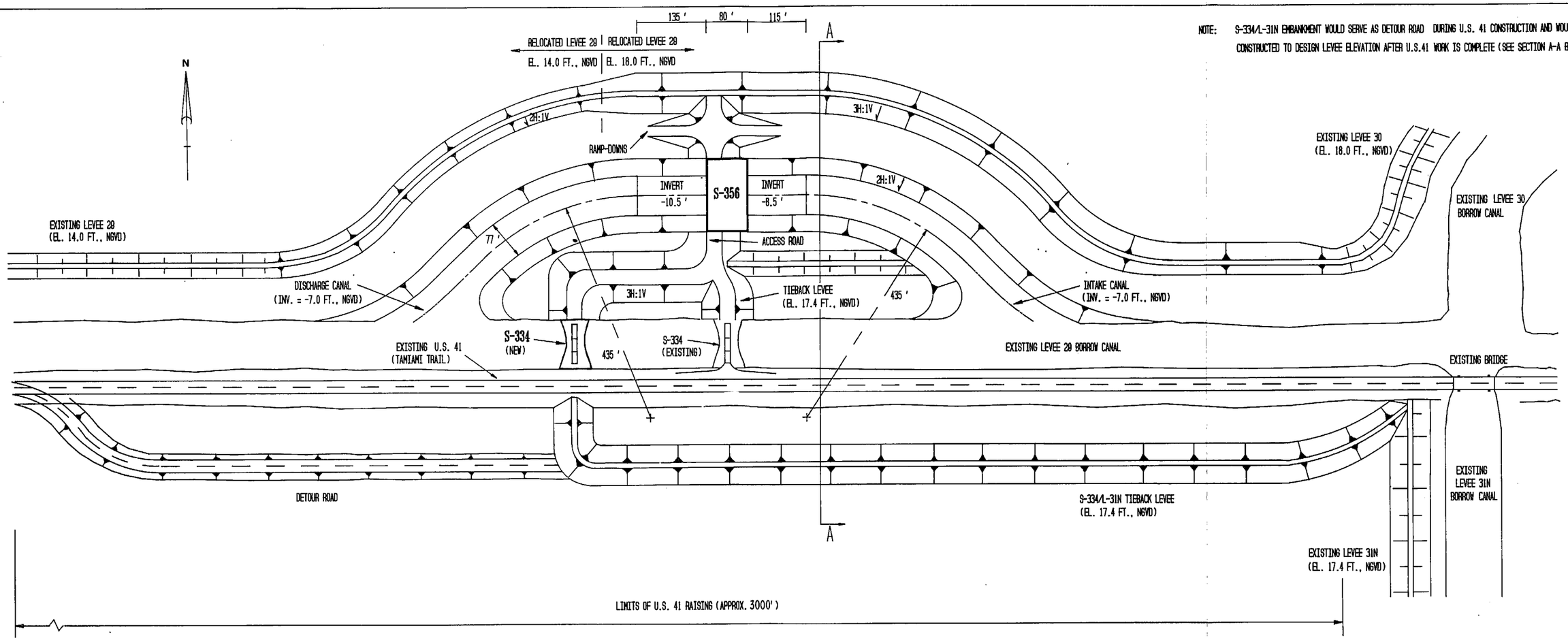
SCALES AS SHOWN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I , SUPP. 54 , DATED: MARCH 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991

NOTE: S-334/L-31N EMBANKMENT WOULD SERVE AS DETOUR ROAD DURING U.S. 41 CONSTRUCTION AND WOULD ONLY BE CONSTRUCTED TO DESIGN LEVEE ELEVATION AFTER U.S.41 WORK IS COMPLETE (SEE SECTION A-A BELOW).

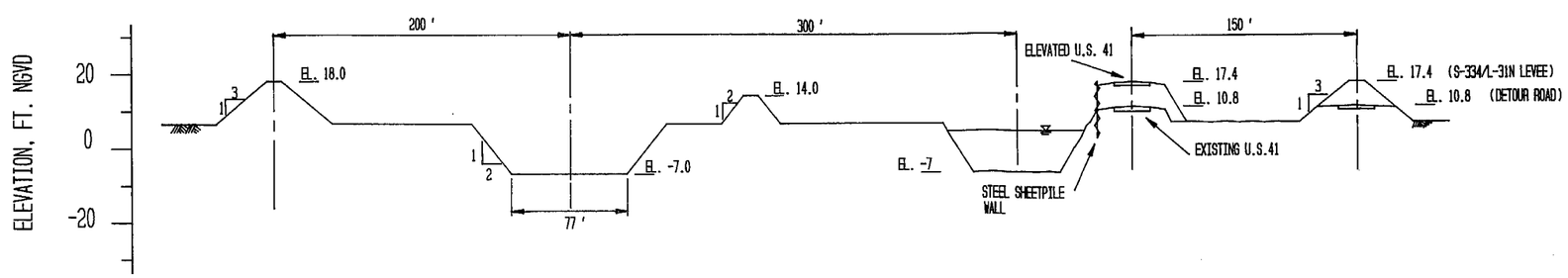


PLAN

SCALE "A"

SCALE "A" 100 ' 0 100 ' 200 '

SCALE "B" 50 ' 0 50 ' 100 '



SECTION A-A

SCALE "B"

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

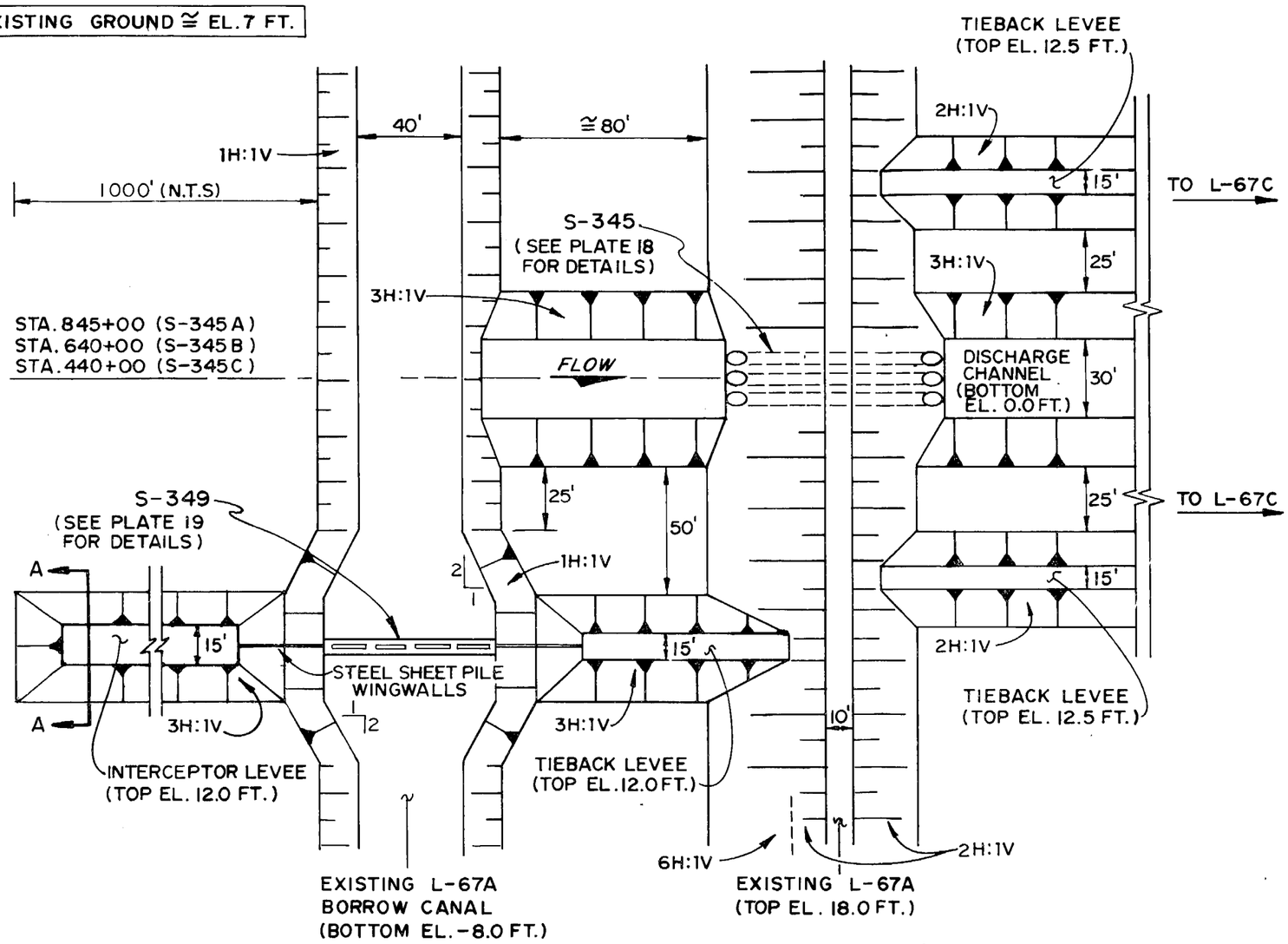
PUMP STATION 356 - PLAN AND SECTION

SCALES AS SHOWN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1 , SUPP.54 , DATED: MARCH 1990
FILE NO. 400-35.662

REV. FEBRUARY 1991



LEGEND

- EXISTING LEVEE
- EXISTING CANAL
- NEW LEVEE
- NEW CANAL

NOTE:

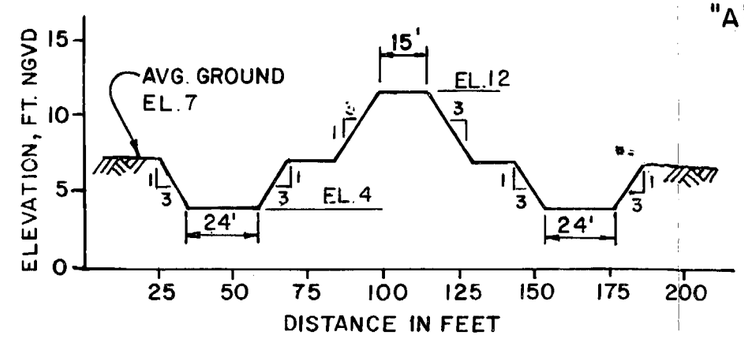
1. BYPASS CHANNEL NOT SHOWN IN PLAN FOR CLARITY.
2. BYPASS TOTAL LENGTH ≅ 2700 FT.

GRAPHIC SCALE

"A" 50' 0 50' 100'

TYPICAL PLAN, VICINITY JUNCTION OF STRUCTURE 345 (A,B,C) AND WITH LEVEE 67A

SCALE: "A" (EXCEPT AS NOTED)



SECTION A-A

(BYPASS CHANNEL AROUND INTERCEPTOR LEVEE)

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

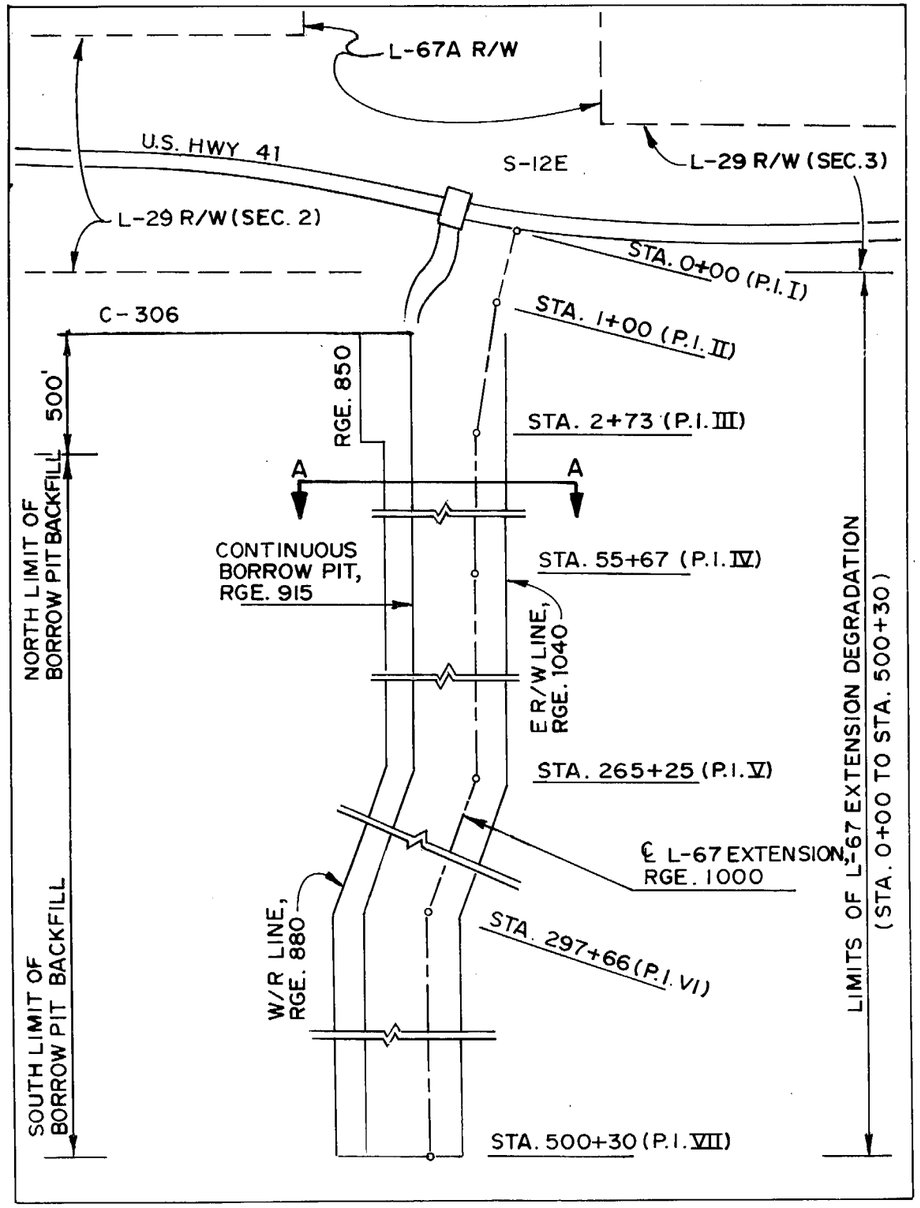
STRUCTURE 345 (A,B,C) AND 349 (A,B,C)
GENERAL PLAN

SCALES AS SHOWN

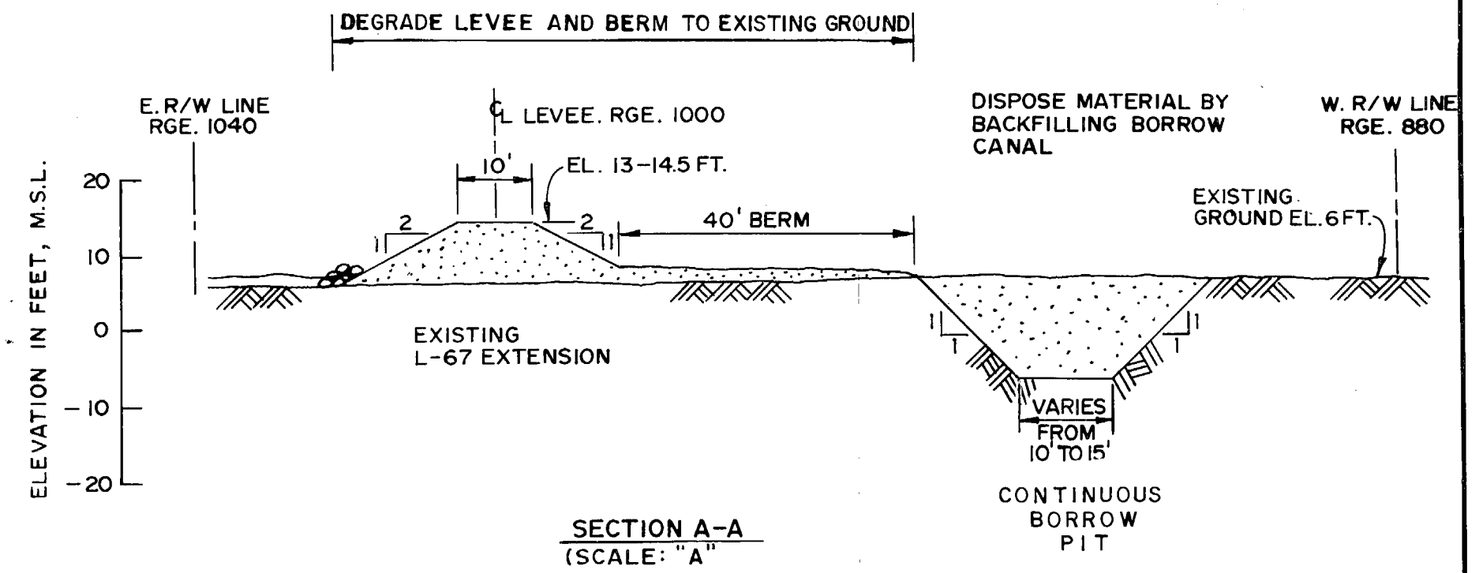
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO., PART I , SUPP. 54 , DATED: MARCH 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991



GENERAL PLAN
(NOT TO SCALE)



SECTION A-A
(SCALE: "A")

NOTE: THREE CULVERT STRUCTURES, S-346, S-347 AND **CULVERT # 4** ARE TO BE REMOVED FROM THE EXISTING L-67 BORROW CANAL AND DISPOSED OFFSITE.

L-67 EXT. COORDINATES AND STATIONING

P.I. NO.	PLANE COORDINATES		REACH NO.	STATION
	X	Y		
I	607,366.25	518,884.25	1	0+00
II	607,329.96	518,791.07	1-2	1+00
III	607,298.81	518,619.99	2-3	2+73
IV	607,483.05	513,529.38	3-4	55+67
V	608,238.18	492,385.08	4-5	265+25
VI	607,263.96	489,293.58	5-6	297+66
VII	607,997.12	469,042.43	6-7	500+30

GRAPHIC SCALE

"A" 20' 0 20' 40'

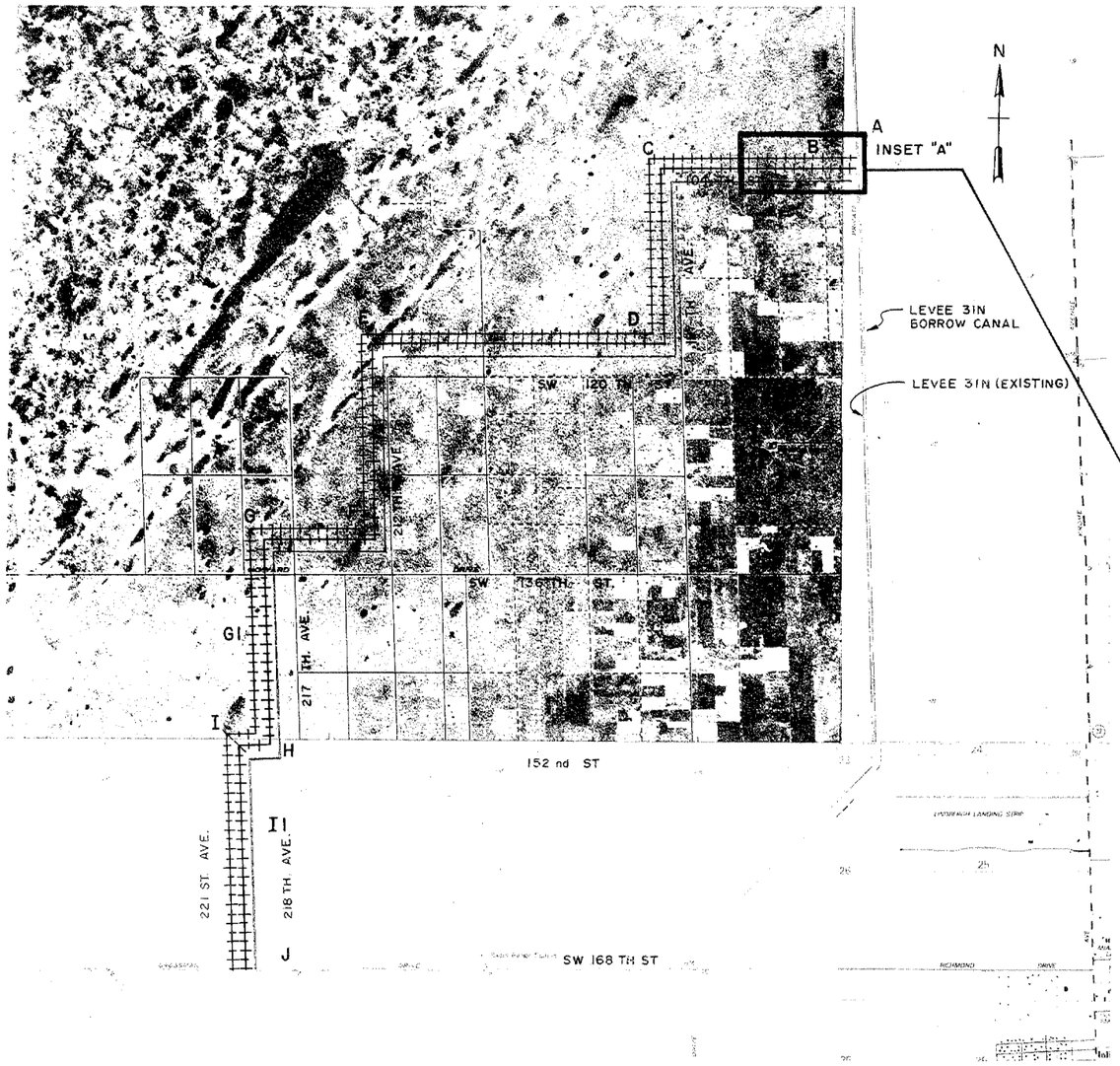
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

LEVEE 67-EXTENSION DEGRADING
GENERAL PLAN AND SECTION

SCALES AS SHOWN

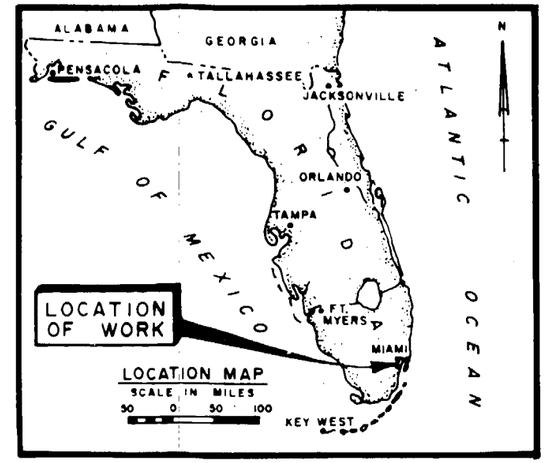
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662



EAST EVERGLADES RESIDENTIAL AREA

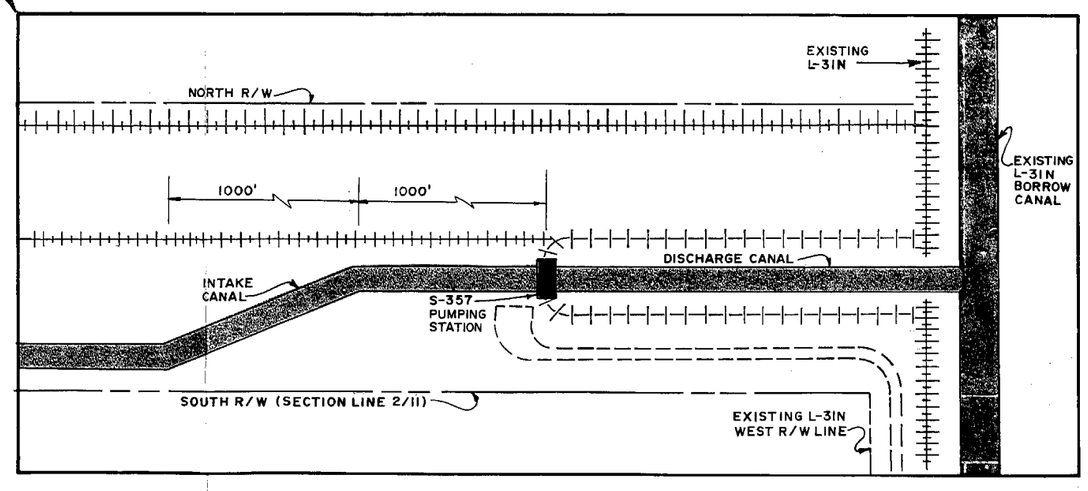
SCALE IN FEET
2000 0 2000 4000



LOCATION MAP
SCALE IN MILES
50 0 50 100

LEGEND

- PROPOSED PUMP STATION
- PROPOSED TIEBACK LEVEE (TOP ELEVATION 12.0 FEET, NGVD)
- PROPOSED OUTER LEVEE (TOP ELEVATION 16.7-19.0 FEET, NGVD)
- PROPOSED INNER LEVEE (TOP ELEVATION 9.5 FEET, NGVD)
- PROPOSED SEEPAGE CANAL
- PROPOSED ACCESS ROAD



INSET "A"
SCALE IN FEET
200' 0 200' 400'

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

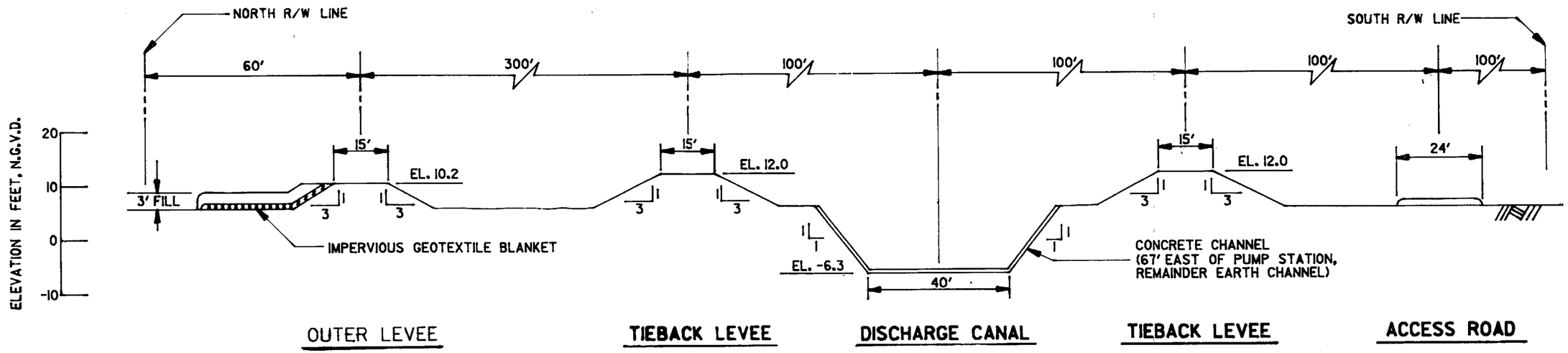
PLAN - RESIDENTIAL AREA

SCALE AS SHOW

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

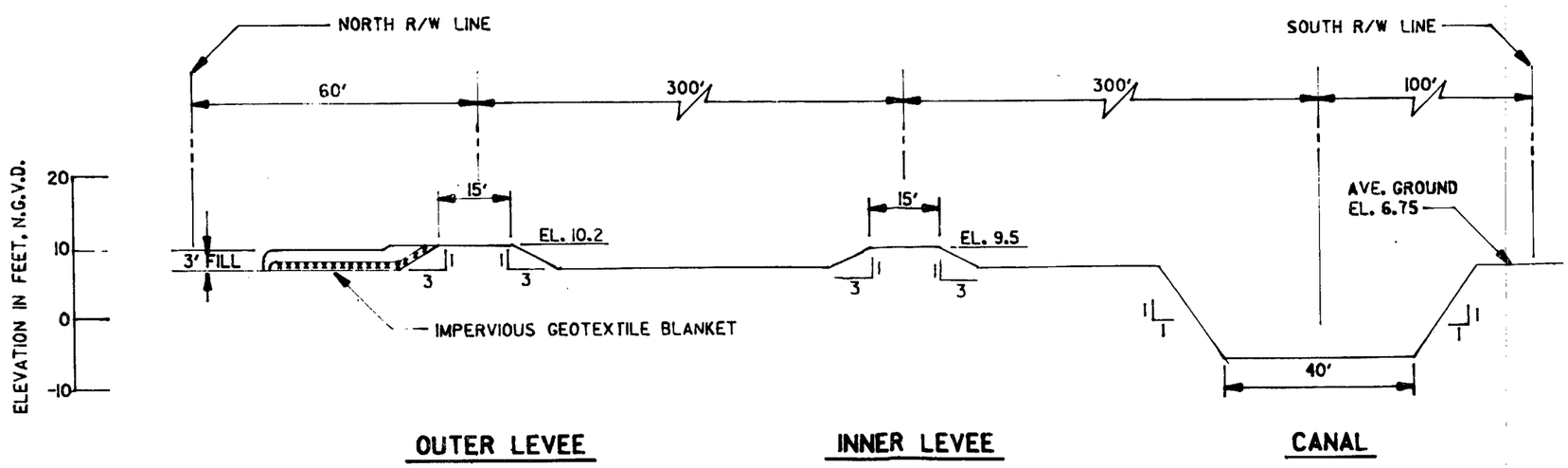
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991



REACH A-B

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)



REACH B-C

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)

NOTES:

1. REACH A-B AND REACH B-C SOUTH R/W LINES COINCIDENT WITH SECTION 2/11 BOUNDARY LINE.
2. ALL SECTION NUMBERS ON PLATES 28 THROUGH 32 REFER TO DADE COUNTY, FLORIDA, RANGER 38 FEET EAST, TOWNSHIP 55 SOUTH
3. REFER TO PLATE 27 FOR REACH DEFINITIONS.

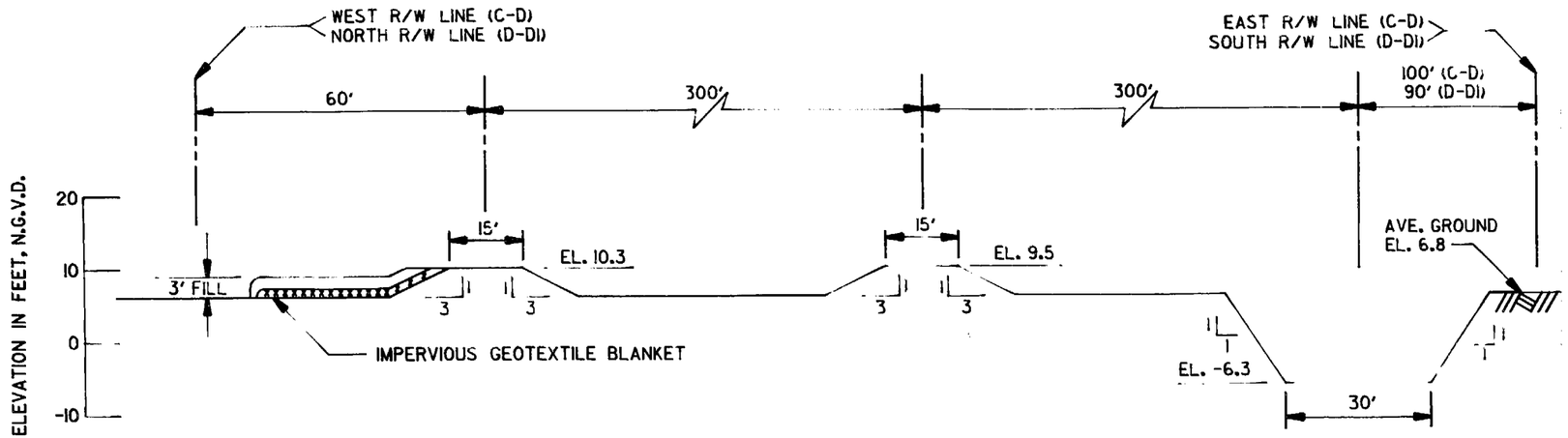
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

SECTIONS (RESIDENTIAL AREA)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

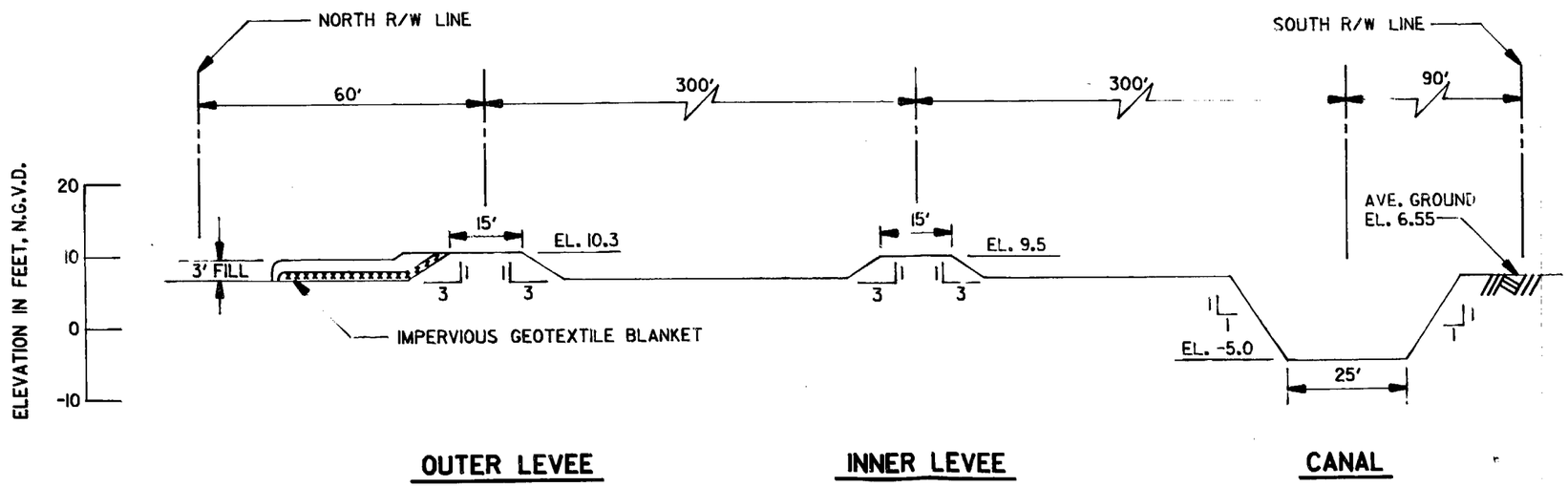
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1, SUPP. 54, DATED: MARCH 1990
FILE NO. 400-95,662

REV. FEBRUARY 1991



REACH C-D / REACH D-DI

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)



REACH DI-E

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)

NOTES:

1. REACH C-D EAST R/W LINE COINCIDENT WITH SECTION 10/11 BOUNDARY LINE.
2. REACH D-DI SOUTH R/W LINE PARALLEL AND 660' NORTH OF SECTION 10/15 BOUNDARY LINE.
3. REACH DI-E SOUTH R/W LINE PARALLEL AND 660' NORTH OF SECTION 10/15 AND 9/16 BOUNDARY LINES.
4. REFER TO PLATE 27 FOR REACH DEFINTIONS.

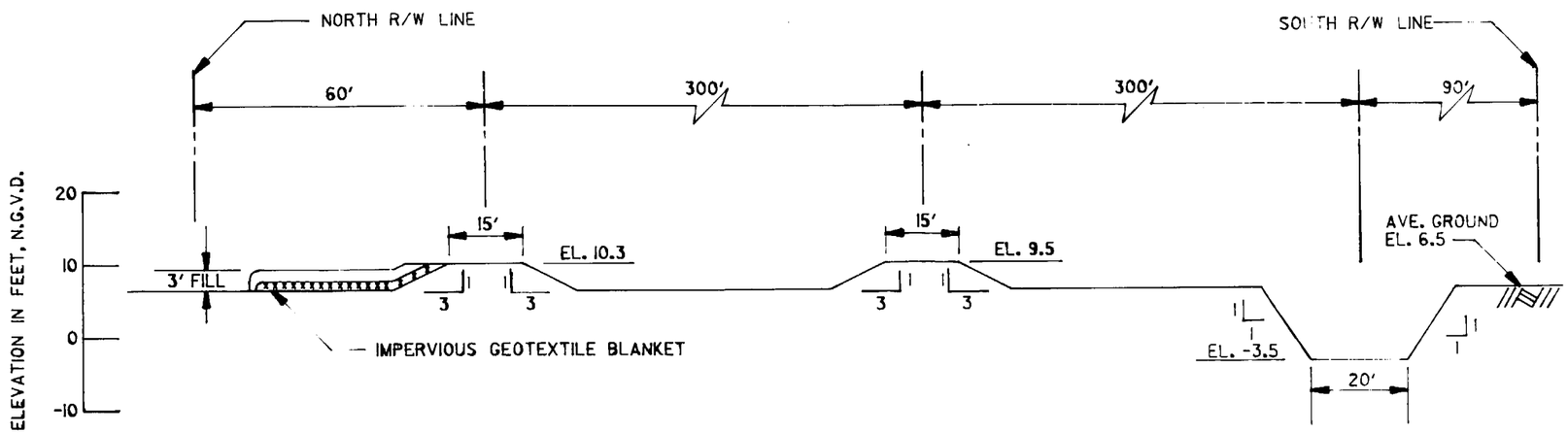
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

SECTIONS (RESIDENTIAL AREA)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

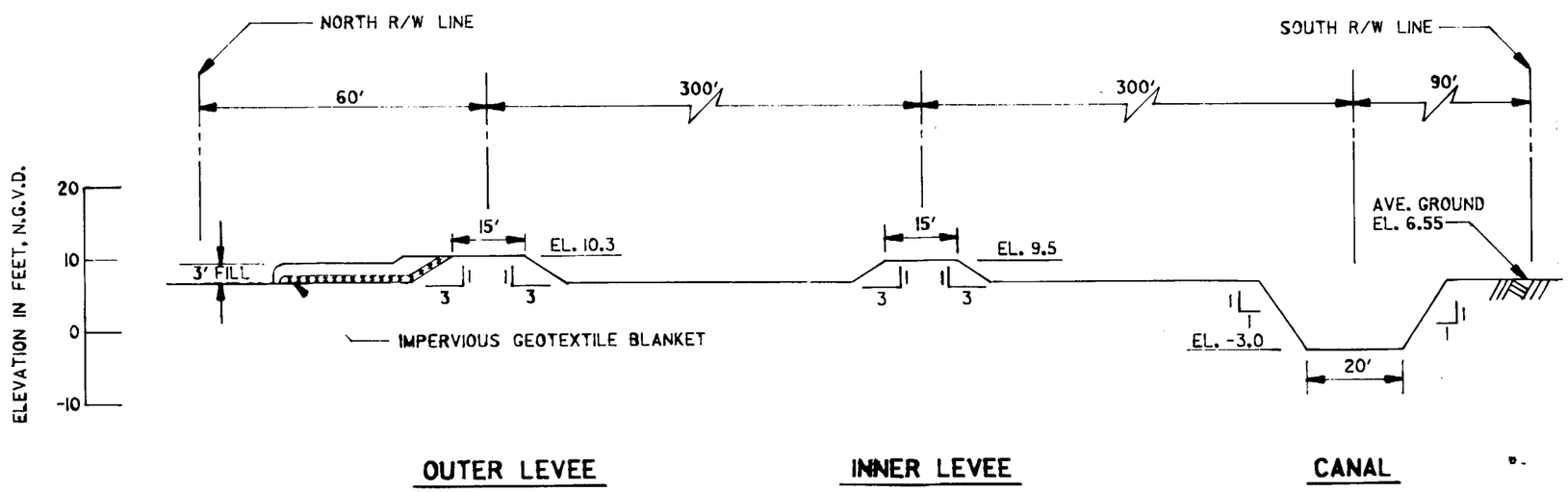
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1, SUPP. 54, DATED: MARCH 1990
FILE NO. 460-35,062

REV. FEBRUARY 1991



REACH E-F

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)



REACH F-G

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)

NOTES:

1. REACH E-F EAST R/W LINE COINCIDENT WITH SECTION 16 HALF-SECTION LINE.
2. REACH F-G SOUTH R/W LINE PARALLEL AND 660' NORTH OF SECTION 16/21 BOUNDARY LINE.
3. REFER TO PLATE 27 FOR REACH DEFINITIONS.

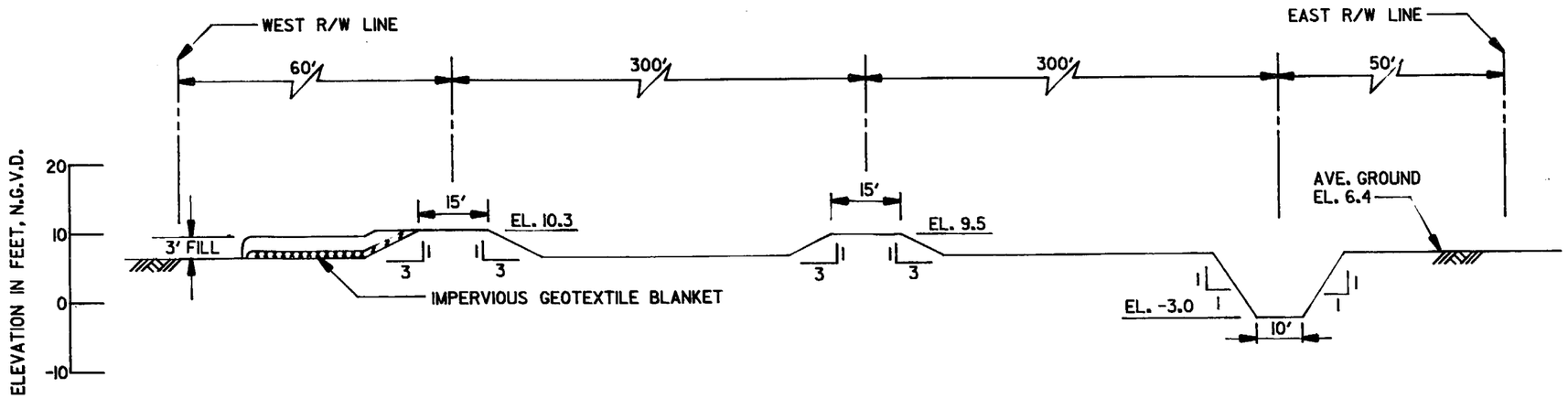
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

SECTIONS (RESIDENTIAL AREA)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

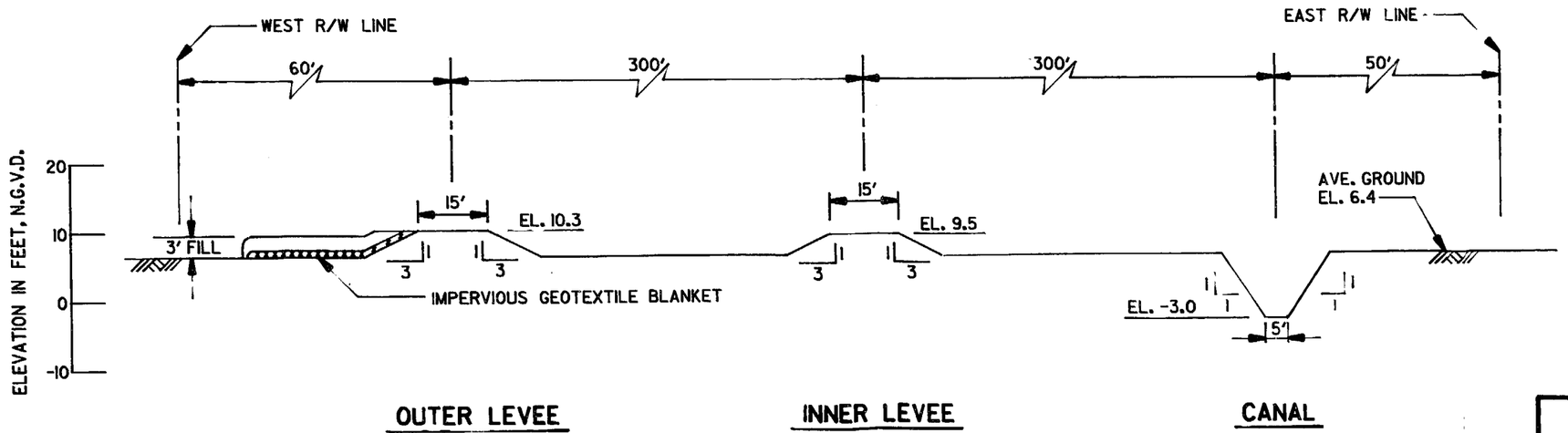
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1, SUPP. 54, DATED: MARCH 1990
FILE NO. 400-38,002

REV. FEBRUARY 1991



REACH G-GI

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)



REACH GI-H

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)

NOTES:

1. REACH G-GI AND REACH GI-H EAST R/W LINE PARALLEL AND 399' WEST OF SECTION 20/21 BOUNDARY LINE.
2. REFER TO PLATE 27 FOR REACH DEFINITIONS.

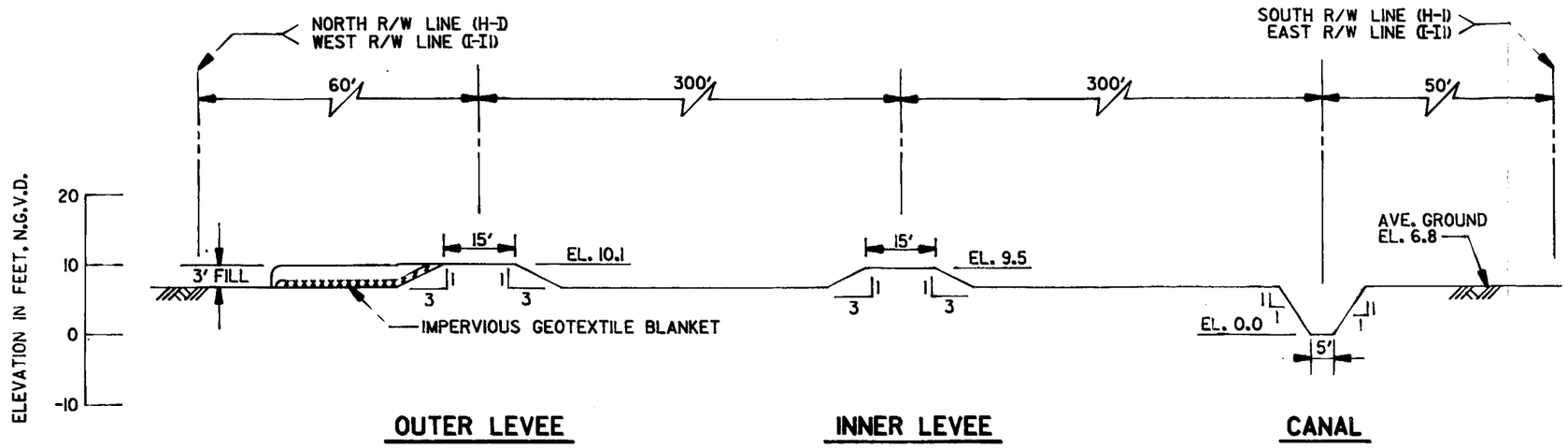
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

SECTIONS (RESIDENTIAL AREA)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

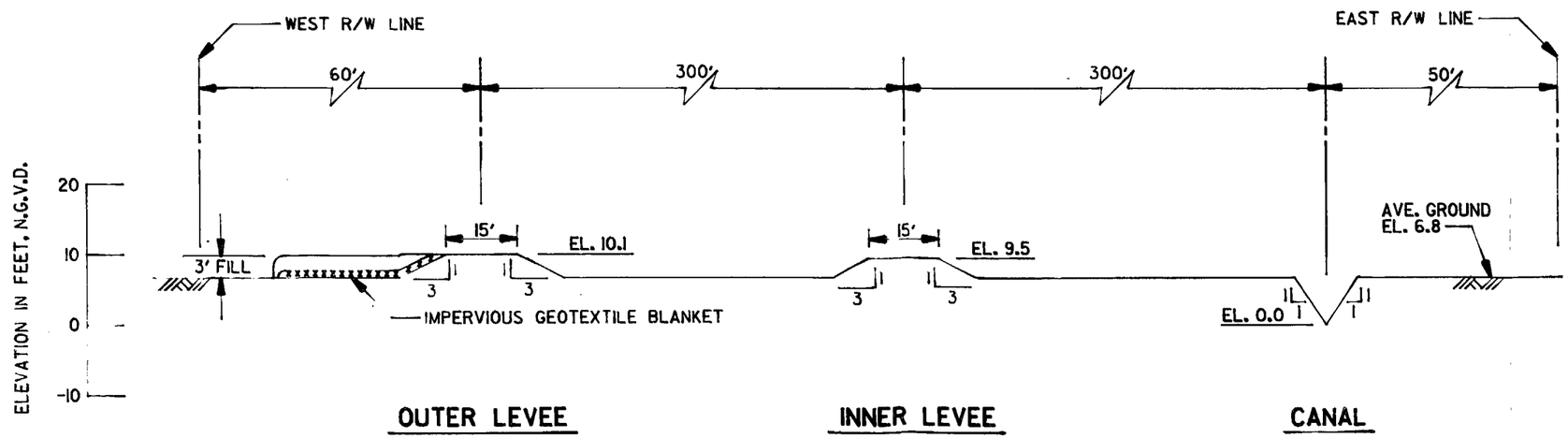
TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1, SUPP. 54, DATED: MARCH 1990
FILE NO. 400-38,662

REV. FEBRUARY 1991



REACH H-I/REACH I-II

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)



REACH II-J

HORIZONTAL SCALE: 1"=30' (EXCEPT AS NOTED)

NOTES:

1. REACH H-I SOUTH R/W LINE PARALLEL AND 330' NORTH OF SECTION 20/29 BOUNDARY LINE.
2. REACH II-J AND I-II EAST R/W LINE PARALLEL AND 1320' WEST OF SECTION 28/29 BOUNDARY LINE.
3. REFER TO PLATE 27 FOR REACH DEFINITIONS.

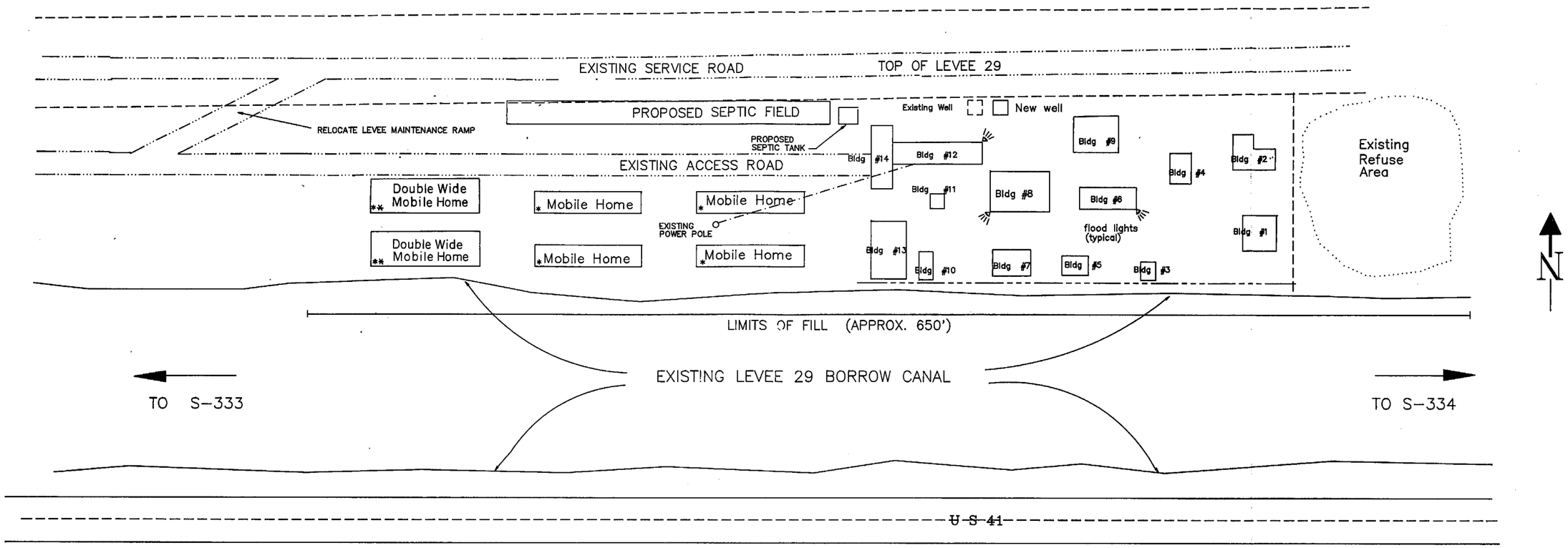
CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

SECTIONS (RESIDENTIAL AREA)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO., PART 1, SUPP. 54, DATED: MARCH 1990
FILE NO. 400-38,662

REV. FEBRUARY 1991



BUILDING	SIZE	CONSTRUCTION	PURPOSE
#1	20'x20'	WOODEN FRAME	STORAGE
#2	20'X24	WOODEN FRAME	RESTROOM
#3	8'X10'	CHICKEE	STORAGE
#4	12'X17'	WOODEN FRAME	LIVING QTRS
#5	11'X14'	CHICKEE	STORAGE
#6	12'X32'	MOD. CHICKEE	COOKING
#7	15'X20'	MOD. CHICKEE	STORAGE
#8	22'X32	MOD. CHICKEE	LIVING QTRS
#9	20'X25'	WOODEN FRAME	LIVING QTRS
#10	8'X16'	WOODEN FRAME	LAUNDRY
#11	8'X8'	WOODEN FRAME	STORAGE
#12	12'X50'	WOODEN FRAME	LIVING QTRS
#13	20'X32'	WOODEN FRAME	LIVING QTRS
#14	12'X36'	WOODEN FRAME	LIVING QTRS
*	12'X60'	MOBILE HOME	REPLACEMENT HOUSING
**	24'X60'	MOBILE HOME	REPLACEMENT HOUSING

PLAN

MICCOSUKEE INDIAN VILLAGE

TIGER TAIL CAMP

SCALE IN FEET

30' 0' 30' 60'

NOTES :

1. BUILDINGS #1 THRU #14 REPRESENT THE APPROXIMATE SIZE AND LOCATION OF THE EXISTING VILLAGE STRUCTURES.
2. EXISTING STRUCTURES #1,#2,#4,#9,#10,#11 #12,#13, AND #14 WILL BE REPLACED WITH FOUR 60'X 12' MOBILE HOMES AND TWO 60'X 24' MOBILE HOMES. CHICKEE STRUCTURES #3, # 5, #6, #7 AND #8 WILL BE CONSTRUCTED IN ORGINAL FASHION. NEW STRUCTURES WILL BE LOCATED TO MATCH ORIGINAL VILLAGE LAYOUT AS MUCH AS POSSIBLE
3. THE SIX (6) MOBILE HOMES WOULD ALSO SERVE AS TEMPORARY HOUSING FOR THE VILLAGERS DURING DEMOLITION AND RECONSTRUCTION OF THE CAMP.

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

MICCOSUKEE INDIAN VILLAGE
TIGER TAIL CAMP

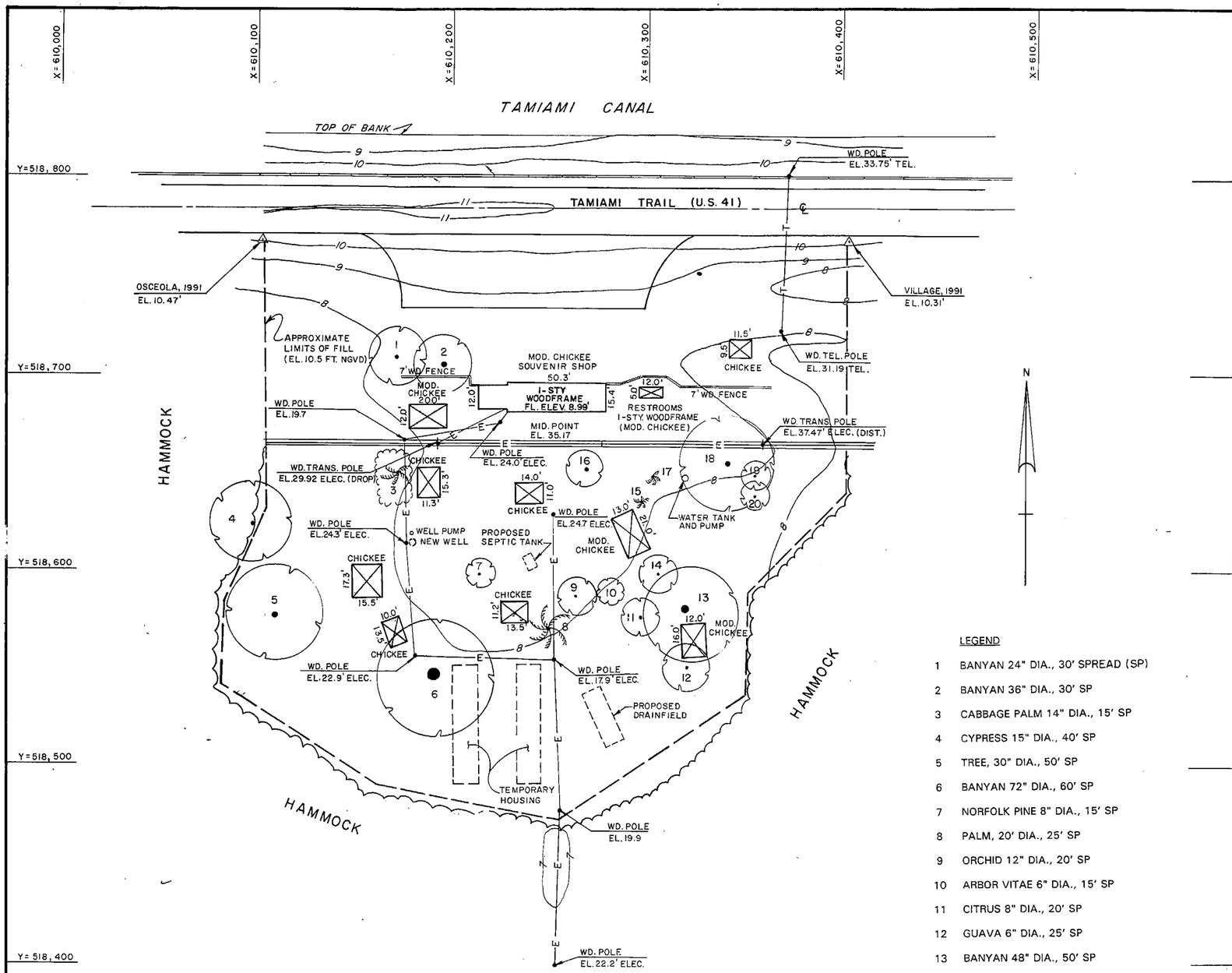
PLAN

SCALES AS SHOWN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

TO ACCOMPANY GENERAL DESIGN MEMO.,
PART 1 ,SUPP. 54 ,DATED: MARCH 1990

FILE NO. 400-35,662



PLAN

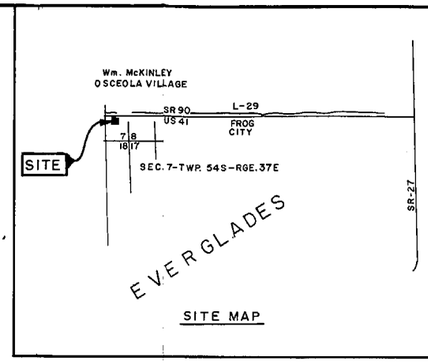
MICCOSUKEE INDIAN VILLAGE
OSCEOLA CAMP

GRAPHIC SCALE

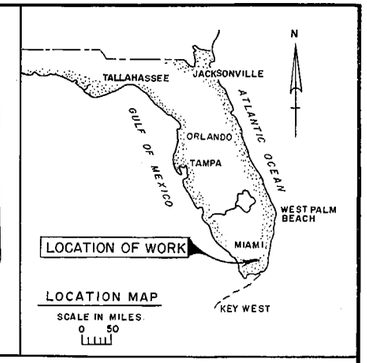
30' 0 30' 60'

LEGEND

1 BANYAN 24" DIA., 30' SPREAD (SP)
2 BANYAN 36" DIA., 30' SP
3 CABBAGE PALM 14" DIA., 15' SP
4 CYPRESS 15" DIA., 40' SP
5 TREE, 30" DIA., 50' SP
6 BANYAN 72" DIA., 60' SP
7 NORFOLK PINE 8" DIA., 15' SP
8 PALM, 20' DIA., 25' SP
9 ORCHID 12" DIA., 20' SP
10 ARBOR VITAE 6" DIA., 15' SP
11 CITRUS 8" DIA., 20' SP
12 GUAVA 6" DIA., 25' SP
13 BANYAN 48" DIA., 50' SP
14 SEAGRAPE 10" DIA., 20' SP
15 COCONUT PALM 15" DIA.
16 BOTTLE BRUSH 24" DIA., 20' SP
17 DATE PALM 6" DIA.
18 BANYAN 36" DIA., 50' SP
19 CITRUS 6" DIA., 15' SP
20 CITRUS 6" DIA., 15' SP



SITE MAP



LOCATION MAP

NOTES:

1. THE PLAN INDICATES THE SIZE AND LOCATION OF THE EXISTING CAMP FACILITIES INCLUDING STRUCTURES (SHADED), UTILITIES, AND TREES. THE NEW REPLACEMENT STRUCTURES WILL BE LOCATED TO MATCH THE ORIGINAL VILLAGE LAYOUT AS MUCH AS POSSIBLE.

2. OTHER PROPOSED IMPROVEMENTS ARE INDICATED IN DOTTED LINES.

3. EXISTING TREES AND SHRUBS WILL BE TRANSPLANTED WHERE POSSIBLE. LARGER TREES INCAPABLE OF BEING TRANSPLANTED WILL BE EVALUATED ON AN INDIVIDUAL BASIS TO DETERMINE IF THEY WILL BE AVOIDED OR REMOVED AND REPLACED WITH SMALLER SPECIES.

CENTRAL AND SOUTHERN FLORIDA
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK, FLORIDA

MICCOSUKEE INDIAN VILLAGE
OSCEOLA CAMP

PLAN

SCALE AS SHOWN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMO., PART I ,SUPP. 54 ,DATED: MARCH 1990
FILE NO. 400-35,662

REV. FEBRUARY 1991

25 June 1992

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Central and Southern Florida Project
Part 1, Supplement 54

The responsible lead agency is the U.S. Army Engineer District, Jacksonville, Florida.

Abstract: The U.S. Army Corps of Engineers has responded to Congressional Authorization and requests by the South Florida Water Management District (SFWMD) to study means to restore the ecosystems of Everglades National Park to the extent practicable through water deliveries from the Central and Southern Florida Flood Control Project. Since ecological restoration is believed to be intricately linked with reestablishment of natural hydrological conditions, planning involved consideration of spatial, temporal, and volumetric aspects of historical water movement. Two alternative structural plans of modification to the C&SF Project were developed for detailed study of the restoration of historical spatial patterns of water flow through the Park. Several alternative operational strategies for use with the new structures were developed to address the timing and volume of water deliveries to the Park. Two operational alternatives with water deliveries keyed to rainfall events were coupled to the Full Structural Plan. The Minimum Structural Plan was coupled with an operation based on the presently authorized minimum delivery schedule. The Full Structural Plan is recommended as best meeting the spatial requirements of water delivery. Initial criteria for operating the C&SF Project with the recommended structures would be developed during the post-GDM design and construction period. Unless more satisfactory criteria are developed by the time the structures are ready for use, the operation identified in this GDM as the Modified Rain-Driven Operational Strategy will be selected for field testing, since it best meets the planning objectives. Operational design of the system to achieve maximum ecosystem restoration of the Park will be developed through a long-term program of field testing and environmental monitoring of interim operating strategies.

This report will be processed in accordance with the procedural requirements of Section 404(r) of the Clean Water Act that are necessary to obtain an exemption from State Water Quality Certification (WQC), if the Federal interest warrants. Concurrently, WQC will be sought from the State.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY AUG 10 1992

If you would like further information on this statement, please contact:

Dr. Jonathan D. Moulding
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232
Telephone: (904) 791-2286

NOTE: Information, displays, maps, etc., discussed in other sections of the GDM are incorporated by reference into the EIS.

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1.04	Authority and Objectives
2.00	ALTERNATIVES, INCLUDING THE PROPOSED ACTION
2.01	Plan Formulation Background
2.02	Recommended Plan
2.03	Minimum Structural Plan
	Description of Structural Features
2.04	Changes in Recommended Plan
2.05	Water Flow Patterns
2.06	Conveyance Between WCA's 3A and 3B
2.07	Controlling Conveyance in L-67A Canal
2.08	Conveyance Between WCA 3B and NESRS
2.09	Interconnection of the Park and NESRS
2.10	Replacement of Existing Structure
2.11	Residential Area Flood Mitigation System
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FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Central and Southern Florida Project
Part 1, Supplement 54

SUMMARY

1. Everglades National Park (Park) is located in South Florida in the southernmost portion of the Everglades. Originally a broad, shallow wetland flowing imperceptibly from Lake Okeechobee to the mangrove zone at the southern tip of Florida, the historic Everglades has been modified by drainage efforts begun in 1881 for agricultural, commercial and residential development, and more recently (since 1948) by the complex of canals, levees, structures, pumps, and impoundments known as the Central and Southern Florida Flood Control (C&SF) Project (Figure 1). With the completion of the project's Water Conservation Areas (WCA) No. 3A and 3B and the southward extension of Levee 67 (L-67 ext.) in the early 1960s, the natural flows to the Park, at the southern terminus of the project, became subject to control by regulation schedule. Discharges were sporadic and based on the competing needs to retain water for urban and agricultural use during the dry season, and to maintain flood control capacity during the wet season. Despite Congressional action in 1970 establishing a minimum monthly schedule of water deliveries through the S-12 structures, the Park experienced ecological decline at an accelerated pace.

2. In 1983, the Park requested that corrective action be taken to reverse wildlife declines in the Park by achieving five hydrologic objectives:

1) Reduce water releases to the Park's Shark River Slough (SRS) Basin through the S-12 structures, especially during normal dry season recession periods.

2) Restore flow distribution across the entire width of SRS, the natural flowway into the Park. This would not only contribute significantly to objective 1, but would also help restore hydroperiods in the eastern portion of the historic SRS Basin [Northeast Shark River Slough (NESRS)].

3) Allow volume and timing of deliveries to fluctuate as they did historically in response to rainfall and antecedent water conditions in the southern Everglades.

4) Maintain downstream SRS water levels at pre-project levels.

5) Maintain water quality so that resource degradation does not occur.

3. The U.S. Army Corps of Engineers was authorized by Congress to study and modify the C&SF Project, as necessary, to improve water deliveries into the Park in order to restore and maintain the Park's natural resources. The Corps accepts the Park's view that a more natural pattern of water flows, at or near historical levels, redistributed across the full cross-section of SRS, is the most likely way to restore and maintain the integrity of its ecosystems. This EIS analyzes structural and operational approaches to achieve the objectives.

4. Two alternative structural plans for spatial distribution of water delivery and three alternative operational strategies of volume and timing of deliveries were developed for detailed study. The recommended Full Structural Plan would provide all the structural features necessary to allow natural movement of water through WCA 3 and then into the northern part of the Park, including the newly authorized expansion of the Park in NESRS. The Basic Rain-Driven Operating Strategy (BRD) was developed to utilize all of these structural features to redistribute delivery water to the Park in consonance with rain events, and to alleviate adverse effects of sudden release of flood waters from WCA 3A. The BRD operation was found by the U.S. Fish and Wildlife Service (USFWS) to constitute jeopardy to the endangered snail kite and to adversely modify its Critical Habitat as a result of the operation's effect of reducing the ponding in WCA 3A that is serving as a drought refuge for the species. Subsequently, an alternative operation for the Full Structural Plan, called the Modified Rain-Driven Operating Strategy (MRD), and a new Minimum Structural Plan coupled with a Modified Minimum Delivery Operating Strategy (MMD) were developed as alternatives to avoid jeopardy. The MRD operation is the same as the BRD operation with the exception of some operational features to maintain water in a kite drought-refuge in WCA 3A. The Minimum Structural Plan coupled with the MMD operation was developed under a strategy to avoid adverse effects on the kite drought-refuge habitat by making no significant changes in the WCA 3A water budget. However, the plan fails to meet the recent Congressional mandate directing the Corps to restore, "to the extent practicable", the "natural hydrological conditions within the park", and would introduce a severe spatial constraint on future water delivery options. Neither of the two non-jeopardy operating strategies is acceptable to all of the participating planning agencies; therefore, neither is recommended. An initial strategy for operating the recommended structures will be developed during the design and construction period over the next several years. Operation of the C&SF Project to achieve the maximum ecological restoration in the Park is expected to be an evolutionary and dynamic process requiring many years of iterative field testing of water delivery strategies in conjunction with an environmental monitoring program by the Park.

5. There is no identifiable National Economic Development (NED) Plan because none of the alternatives provide any net NED benefits.

6. The Full Structural Plan is recommended because it provides more flexibility for future operational testing to meet the Congressional mandate to restore natural hydrological conditions in the Park to the extent practicable.

AREAS OF CONTROVERSY.

7. Navigational access. A new area of controversy developed during public review of the DEIS. Previous coordination had not revealed the importance to the sport fishing public of navigational access along the L-67 canals. The S-349 structures described in the DEIS totally blocked boat access to the middle 2 miles of the L-67A Canal and the northern half of the L-67C Canal, and blocked boating access to the southern half of the L-67A Canal from the northern boat ramps. Design changes to spread the structures farther apart have been incorporated into the final recommended plan at the request of the Park, EPA, and others. This would further aggravate the issue by isolating a longer middle reach of the L-67A Canal and by blocking more of the L-67C Canal. The issue was addressed by adding a half-mile long bypass channel for each structure into the recommended plan. This would allow slow-passage access to the middle 7 miles of the L-67A Canal, but there is still no access to the upper two thirds of the L-67C Canal.

8. Choice of operating strategy. Another important area of controversy at this time concerns the choice of the MRD Operational Strategy as the provisionally recommended operation for the Full Structural Plan. The original operation (BRD) developed jointly by the Corps and the SFWMD became unacceptable when the U.S.Fish and Wildlife Service (USFWS) determined that the operation would jeopardize the continued existence of the endangered snail kite, a species listed under the Endangered Species Act. The alternatives developed to avoid jeopardy have differing degrees of acceptability to other agencies. All of the agencies that played a major role in the GDM planning appear to agree on the need for the full structural features to optimize spatial aspects of future operational strategies, and for that reason do not prefer the Minimum Structural Plan. The Florida Game and Fresh Water Fish Commission (FGFWFC) states that it would object to the discharge of "poorer quality water" from the L-67A canal across WCA 3B. The FGFWFC would remove this objection only after the nutrient reduction goals of the SFWMD's Everglades Surface Water Improvement and Management (SWIM) plan are reached. This is estimated to require perhaps as much as 10 years. The Corps' assessment that implementation of the Full Structural Plan would not adversely affect water quality in WCA 3B is presented in the body of the EIS. The Park and several reviewers disagree with the USFWS's snail kite analysis for the BRD Operation and object to giving single-species management a priority over ecosystem restoration. However, the Corps recognizes that endangered species considerations have an institutional priority by law. The SFWMD continues to have serious reservations about the MRD operation, and have stated that they cannot agree to it until "detailed analysis is performed and the potential impacts [on regional water supply] are known and found acceptable." This issue is aggravated by the extreme drought that occurred in South Florida recently.

9. Water quality concerns in residential area flood mitigation. The previously identified potential controversy involving the flood mitigation feature for the 8-1/2 sq. mi. residential area did not arise in comments on the DEIS from the Florida Department of Environmental Regulation (DER). However, other reviewers have also expressed some concern about possible adverse water quality effects associated with introducing floodwater-pumpage

from the residential area back into NESRS as follows. EPA has recommended building a water retention basin for pre-treatment of internal drainage water before release. The Dade County Department of Environmental Resources Management (DERM) has requested a low berm be built adjacent to the collector canal to hold back the first 2" of stormwater runoff. The Park has asked for a buffer strip of undeveloped land adjacent to the canal to preclude nearby sources of pollution.

10. Wetlands Impact. The Dade County Planning Department and DERM have objected to a change in the recommended plan of residential flood mitigation that would exclude from the Park expansion area 200 acres of wetlands adjacent to the residential area. This resulted from a change the Corps made in the original recommended plan during public coordination of the DEIS. Portions of the residential levee alignment have now been shifted approximately 400 to 660 feet farther outward into wetlands initially designated for the Park expansion in order to avoid social impacts on eight families with residences that were scheduled to be bought and razed as part of the Federal acquisition. This separated from the Park and included within the residential flood mitigation levees an area of about 138 acres of good quality wetlands and 62 acres of poorer quality wetlands. The proposed operational design of the system for flood mitigation would not significantly change the existing hydrology within the levee, and therefore, wetlands would not be lost to overdrainage. Dade County, however, believes that political pressure may be brought to bear in the future to operate the system to provide flood protection benefits for development, resulting in overdrainage.

RESOLUTION OF ISSUES

11. Navigational access. The recommended plan has been revised to provide navigational access around each of the S-349 structures in the L-67A Canal by means of a slow-speed bypass channel. There is no practical way to provide access to the northern two thirds of the L-67C Canal. It is likely that some elements of the fishing public will object to the loss of access to the upper reaches of the L-67C Canal and will resent the necessity to slow down at the structures in the L-67A Canal. The revised plan, therefore, may not be a satisfactory solution for them.

12. Choice of operating strategy. The issues concerning an operational strategy for the water delivery system are expected to be resolved through extended coordination and reformulation during the design and construction period over the next few years.

13. Snail kite. The snail kite Jeopardy Biological Opinion issued by the USFWS is the position of the Department of Interior. The selection of the MRD Operation resolves this issue for the time being. However, it is expected to surface again during further operational planning over the next several years. The Corps would request that the USFWS review the snail kite opinion on the BRD Operation if new information gathered during kite field studies being considered by others so warrants.

14. WCA-3B. The FGFWFC's objections are expected to be resolved through the FEIS commitments to providing "real time" water quality criteria for operation

of the S-345 structures into WCA 3B and the recommended features for fishing access along L-67A.

15. Regional water supply. The SFWMD's reservations about accepting the MRD Operational Strategy because of concerns about regional water supply impacts are expected to be resolved by the additional evaluations provided in the revised GDM.

16. Residential area water quality. Dade County's and the Park's requests for water quality control features for the residential area are expected to be resolved by the inclusion of an approximately 600-foot wide undeveloped buffer strip between the conveyance-collector canal and the inner edge of the Federally acquired right-of-way (ROW) with an 18-inch high berm along the inner edge to prevent surface water flow into the ROW from the outside development area. EPA's recommendation for a retention area for water treatment are not considered practical because of the high porosity of the land (see response to EPA comment in EIS Appendix F).

17. Wetlands impacts. Dade County has agreed with the Corps' request to defer the resolution of the residential levee alignment issue until the detailed engineering design phase. The compromise resolution may be to move the alignment back to some extent, particularly along SW 120th Street where only one home and a horse pasture is involved in the separation of the good quality wetlands. The overdrainage issue is expected to be resolved by giving Dade County an active role in determining the operating criteria for the residential flood mitigation system.

UNRESOLVED ISSUES.

18. There are no unresolved issues for this phase of the project. There are some issues that will be carried over to the detailed engineering design phase that will follow this GDM.

1.00 PURPOSE OF AND NEED FOR ACTION.

1.01. Origins of the Problem. Everglades National Park is located within the Everglades ecosystem in extreme South Florida. Originally a broad, shallow wetland flowing imperceptibly from Lake Okeechobee to the mangrove zone at the southern tip of Florida, the historic Everglades has been modified by drainage efforts begun in 1881 for agricultural, commercial, and residential development, and more recently (since 1948) by the complex of canals, levees, structures, pumps, and impoundments known as the Central and Southern Florida Flood Control (C&SF) Project (Figure 1). With the completion of the project's Water Conservation Areas 3A and 3B (WCA 3A and WCA 3B) and the southward extension of Levee 67 (L-67 ext.) in the early 1960s, the natural water flow to the Park, at the southern terminus of the project, became subject to control by regulation schedule. Discharges were based on the competing needs to retain water for urban and agricultural use during the dry season and to maintain flood control capacity during the wet season.

1.02. Early Attempts to Alleviate the Problem. Following severe impacts to the Park from droughts in the mid-1960s, Congress, using the best information available at the time, established a minimum water delivery schedule to protect Park resources. (P.L. 91-282). Delivery of a guaranteed minimum annual water supply in specified monthly quantities, however, created new problems. The release of water to the Park from WCA 3A still was constrained in part by needs of other consumers and the requirement for disposing of excess water during high water periods. Stages (water levels) in the Park occasionally were caused to increase unnaturally during the dry season. Moreover, the delivery of water from WCA 3A was directed to the west side of the main flowway to the Park, Shark River Slough (SRS), altering hydropatterns in the Park and abbreviating the hydroperiod in the adjacent privately-owned Everglades to the east, Northeast Shark River Slough (NESRS). This has severely disrupted wildlife feeding and nesting patterns in the Park, leading to population declines and other ecosystem perturbations.

1.03. Everglades National Park's Request. In the mid-1980s the Park requested that corrective action be taken to achieve five hydrologic objectives:

1) Reduce water releases to the Park's SRS Basin through the S-12 structures, especially during normal dry season recession periods.

2) Restore flow distribution across the entire width of SRS, the natural flowway into the Park. This would not only contribute significantly to objective 1, but would also help restore hydroperiods in the eastern portion of the historic SRS Basin (including NESRS).

3) Allow volume and timing of deliveries to fluctuate as they did historically in response to rainfall and antecedent water conditions in the southern Everglades.

4) Maintain downstream SRS water levels at pre-project levels.

5) Maintain water quality so that resource degradation does not occur.

1.04. Authority and Objectives. Congress addressed the Park's request in the Supplemental Appropriations Act of 1984 and the Everglades National Park Protection and Expansion Act of 1989 (EIS Appendix A). By these Acts, the Corps of Engineers (Corps) was "authorized and directed to construct modifications to the Central and Southern Florida Project to improve water deliveries into the park", and, "to the extent practicable, take steps to restore the natural hydrological conditions within the park". In a planning process coordinated with the participating planning agencies, the Corps developed as criteria for improved water deliveries the restoration and maintenance of the natural abundance, diversity and ecological integrity of native plants and animals within the Park as they existed in the mid-1930's when the Park was authorized by Congress. The Corps' findings and recommendation for achieving the restoration objectives are presented in this GDM.

2.00 ALTERNATIVES, INCLUDING THE PROPOSED ACTION

2.01 Plan Formulation Background. Initially, hydrologic criteria were established for restoring natural water conditions in SRS. A Full Structural Plan of modification to the C&SF Project was developed to implement spatial aspects of the criteria and to provide the maximum operating flexibility for temporal and volumetric aspects of water delivery (Plate 6). A range of operations was then developed to accomplish the hydrologic goal. Extensive coordination of the preliminary plans resulted in a consensus for an operational strategy of water deliveries to SRS based on rainfall and water levels in WCA 3A. This operation was applied to the Full Structural Plan and is called the Basic Rain-Driven Operational Strategy (BRD). Two new formulations were evaluated after additional coordination with the U.S. Fish and Wildlife Service (USFWS) showed that the BRD operation would adversely modify designated Critical Habitat of an endangered species (the snail kite). The first was an alternative operation for the Full Structural Plan that is called the Modified Rain-Driven Operational Strategy (MRD) that would maintain the necessary kite habitat. The second was an alternative Minimum Structural Plan (Plate 8) coupled with a Modified Minimum Delivery Operational Strategy (MMD) that would not affect existing kite habitat. In addition, the No-Action Plan (Base Condition) was carried through plan formulation.

2.02 Recommended Plan. Construction of the features of the Full Structural Plan (described in paragraphs 2.05-2.14) is recommended to allow the water management flexibility to implement a wide range of potential operational options as they are developed in the future. This would be coupled with the MRD Operational Strategy as described in paragraphs 2.16 and 2.22. Further recommended as a plan element is an interagency coordination process during the post-GDM design and construction period to develop and model new operational strategies leading to selection of the best one to begin field testing. Any new strategy proposed would be subject to NEPA review and coordination under the Endangered Species Act. At the time that construction is complete (circa 1997) and sufficient land in NESRS has been acquired, the MRD operation would be implemented only if a more satisfactory one had not been developed. This would be the first step of an extended iterative modeling and field testing program for the purpose of developing an operational plan that best achieves the restoration objectives as determined through an interagency environmental monitoring program (paragraph 2.23). Any subsequent steps would also be subject to the coordination described above.

2.03 Minimum Structural Plan. This plan was developed as an alternative means of avoiding adverse impacts on the Critical Habitat of the snail kite in WCA 3A. Subsequent to its development, Congress mandated that the Corps restore, to the extent practicable, the natural hydrological conditions within the Park (P.L. 101-229, see EIS Appendix A). The inability of this plan to allow for conveyance of water through WCA 3B would severely limit future operational options for hydrologic restoration of the Park, thereby creating potential obstacles to meeting the Congressional mandate.

2.04 Changes in Recommended Plan. The following changes, described in subsequent paragraphs, have been made in the recommended plan since the DEIS was issued.

a. At the suggestion of the Park and EPA, the S-349/S-345 structures have been moved farther apart along L-67A. In terms of distances along the levee, structures A, B, and C are now located approximately 15.9, 12, and 8.9 miles north from the Tamiami Trail, respectively. This compares with the original locations of 14.3, 13.1, and 12 miles, respectively. The new "B" structure location is the same as the original "C" structure.

b. A small bypass channel has been provided around the interceptor levee at each of the S-349 structures to allow uninterrupted navigation for anglers along the full length of the L-67A Canal.

c. The 8 1/2 sq. mi. residential area flood mitigation features have been redesigned as follows:

1. The S-357 pump station has been upsized from 470 cfs to 533 cfs and relocated to the junction of the collector canal and the L-31(N) Canal.

2. The internal conveyance canal adjacent to Howard Drive has been eliminated.

3. The perimeter levee and canal have been moved farther outward into undeveloped wetlands to avoid eight homes as follows: 660 feet farther westward adjacent to SW 218th Avenue, 400 feet farther westward adjacent to SW 218th Avenue, 660 feet farther northward adjacent to Howard Drive, and 660 feet farther northward adjacent to SW 120th Street.

DESCRIPTION OF STRUCTURAL FEATURES

2.05 Water Flow Patterns. Simplified representations of where water flows under the Base Condition (No-Action alternative) and where it would flow during operation of the recommended Full Structural Plan and the Minimum Structural Plan are presented in Figures 2, 3, and 4 respectively.

2.06 Conveyance between WCA No.s 3A and 3B. Under the Full Structural Plan, three sets of gated culverts (S-345A, B, C) each with a capacity of about 500 cfs, would be constructed in L-67A, evenly spaced between S-151 and S-333. Water discharged through the culverts would be conveyed from WCA 3A into WCA 3B via canals with containment levees between L-67A and L-67C. The purpose of the culverts would be to provide a means for introducing into WCA 3B surface water that could be delivered to NESRS. Currently, virtually the only sources of outside water to WCA 3B are direct rainfall and under-levee seepage.

2.07 Controlling Conveyance in L-67A Canal. Under the Full Structural Plan, three sets of gated water control structures (S-349A, B & C) would be constructed in the L-67A canal at distances from the Tamiami Trail of 15.9, 12, and 8.9 miles, respectively. One of these structures would be constructed immediately downstream of each of the S-345 structures. The S-349s would

accomplish two functions: block flows down the L-67A canal under flood and normal hydrological conditions so as to force more sheet flow through WCA 3A, and increase water discharges into WCA 3B via the S-345s by creating higher headwater stages. This would provide a more even distribution of water within WCA 3. The structures when opened could pass the full canal capacity under drought conditions in order to convey water to the Park and south Dade County. The structures could also be opened when necessary to pass water to southern WCA 3A in order to preserve a pool of water, if needed, to provide adequate drought refuge for the snail kite, a Federally listed endangered species.

2.08 Conveyance between WCA 3B and NESRS. Also under the Full Structural Plan, two gated water control structures (S-355A & B) would be constructed in L-29 between S-333 and S-334. The structures would each have a capacity of 1,000 cfs to discharge water from WCA 3B into NESRS. These structures, in conjunction with the S-345s and the S-349s would be used to restore WCA 3B as a hydrologically functioning component of the Everglades system. A collection canal would be provided immediately upstream of the structures and discharges would be passed into the L-29 canal. Water would flow south from the L-29 canal through fifty-two existing culverts located under the adjacent section of the Tamiami Trail (U.S. Highway 41) into NESRS across a ten-mile section that includes the center of the historic flow-way.

2.09 Interconnection of the Park and NESRS. This and subsequently described structural features are common to both structural plans. L-67 ext. would be degraded and used to fill, to the extent possible, the adjacent borrow canal. This would remove an existing impediment to full hydrologic integration of SRS within the expanded Park boundary.

2.10 Replacement of Existing Structure. Structure S-334 is an existing component of the Everglades National Park/South Dade County Conveyance System. It would be replaced with a new structure to enable holding higher water levels in the upstream L-29 canal. A short section of U.S Highway 41 would also have to be raised, and levees would be added to tie into L-30 to the north and L-31 to the south.

2.11 Residential Area Flood Mitigation System. A flood mitigation system would be constructed for the residential area referred to as "the 8 1/2 sq. mi. area" in the East Everglades. The purpose of the system would be to prevent the area from being subjected to increased flood risk from higher stages in NESRS as a result of modified water deliveries to the Park. It would consist of a double levee surrounding the area to the north and west tied into L-31N (the south side would be open) and a seepage collection canal within the leveed area to pass seepage water and local runoff to a 533 cfs pump station, S-357, on the east end that would pump excess water into the L-31N canal for conveyance north (Plate 27). A 760-foot right-of-way (ROW) would be acquired in fee-simple title by the Corps for the perimeter canal and levees. During the detailed engineering design phase following this GDM, the Corps will analyze if the double levee could be replaced with a single levee. In either case, the ROW would remain at 760 feet.

2.12 Recycling Seepage and Floodwater from NESRS. A 1000 cfs pump station (S-356) would be constructed adjacent to S-334 (Plate 24). The pump station

would pump excess water from the L-31N canal into the L-29 canal whenever stage in the former exceeded 5.5 feet NGVD. The water would then flow back into NESRS through the existing culverts. The excess water would consist of (1) flood waters conveyed north in the L-31N canal from the residential area (introduced via S-357) and (2) increased seepage inflows to the L-31N canal caused by higher water levels in NESRS.

2.13 Flood Protection Associated with the Tamiami Canal. Raising the average stage of the Tamiami Canal would cause inundation of the Tiger Tail Miccosukee Indian Camp located between the canal and L-29 (Plate 33). Therefore, each plan includes using fill to raise the ground elevation at the camp site by about 3 feet. The dwellings would then be relocated or rebuilt on top of the new fill.

2.14 Navigational Access in L-67A Canal. To provide small-boat navigational access to the 7 miles of canal lying between S-349A and S-349C, a bypass channel would be constructed around each of the 1000-foot long interceptor levees extending out from the S-349 structures into the WCA 3A marsh. The channels are dimensioned for a design boat of 17-foot length, 6-foot beam, and draft of about 2.5 feet when off-plane. This corresponds to the typical bass boats used by fishermen in the canal. The channels would have a bottom width of 24 feet at a design elevation of 4.0 feet NGVD. The top width at marsh elevation (7.0 feet NGVD) would be approximately 42 feet (3H:1V sideslopes). The channels would have an 85-foot radius of bend around the end of each levee to provide a safe line of sight for oncoming boats. Each bypass channel is about 2850 feet long, 500 feet of which will lie within the existing 100-foot wide berm paralleling the west side of the L-67A canal (Main Report, Figure 21).

ALTERNATIVE OPERATIONAL STRATEGIES

2.15 Basic Rain-Driven Operational Strategy (BRD). This operation was applied to the Full Structural Plan and has the following features. The timing of water deliveries from WCA 3 into the Park would be based on two components: rainfall and stages in WCA 3A. The rainfall component would be computed using a regression equation developed by the SFWMD through a correlation of historic rainfall vs. historic flow to the Park. The stage component would be based upon average water levels in WCA 3A and would be intended to gradually increase flood releases from the area when necessary under a new WCA 3A regulatory schedule (Plate 16). Under normal or dry conditions, the stage component would be zero, and all water deliveries would be based upon the rainfall component. The operational target for distribution of all water deliveries across the full width of SRS is to deliver 45% through the S-12s and 55% into NESRS via the S-355s (and/or S-333 when needed to achieve 55%). This is an interim target developed by the SFWMD and the Park that is subject to change as knowledge and field experience expands. Operations at each structure are summarized below:

a. S-345s: Discharges through these three recommended new structures would begin when water levels in WCA 3A rise to within 0.5 feet of the regulation schedule and would gradually increase to capacity when water levels reach 0.5 feet above the schedule.

b. S-349s: Under most conditions these three recommended new structures would be closed and would block flow down the L-67A canal. However, discharges would be made when water supply deliveries to the Park/South Dade County Conveyance System (i.e., L-67A canal, L-29 canal, L-31N canal, C-111, and the coastal canals) are needed. The Park water supply from this system refers to deliveries to Taylor Slough through S-332 and to the eastern panhandle of the Park through the C-111 gaps.

c. S-12s: These four existing structures (each rated at 8000 cfs) would be used to discharge 45% of the combined rain-driven computed deliveries and regulatory flows to the Park.

d. S-355s: Use of these two recommended new structures would be the first priority for discharging to NESRS 55% of the total water flows via the existing 52 culverts under the Tamiami Trail. However, when the structures do not have adequate capacity to pass the required rate of flow, supplemental discharges into the L-29 canal would be provided through S-333 and from there into NESRS through the existing culverts.

e. S-333: This existing structure (rated at 1300 cfs) would continue to be used to pass water supply discharges from WCA 3A to the Park/South Dade County Conveyance System. It would also be used to deliver water into NESRS, as necessary, when the S-355s did not have adequate capacity to achieve the 55% split described above.

2.16 Modified Rain-Driven Operational Strategy (MRD). This operation, which also applies to the Full Structural Plan, differs from the BRD operation only in several operational features designed to minimize adverse effects on the snail kite, a species protected under the Endangered Species Act. The USFWS has determined that the southeast corner of WCA 3A provides important drought-refuge habitat for snail kites because it is generally one of the last areas in the Everglades to dry out. To help maintain the existing pool of water in this designated snail kite Critical Habitat, the S-349s would be left open at all times to facilitate conveyance of water to the southern end of WCA 3A. If necessary during droughts, an additional two actions would be taken: Supplemental water from Lake Okeechobee would be delivered to WCA 3A at the maximum conveyance capacity of the Miami Canal when the average stage in WCA 3A is at or below 9.0 feet NGVD (under the BRD Operation and Base Condition this occurs at 8.5 feet NGVD). Also, when water levels in the L-67A Canal upstream of S-333 fell to or below 7.5 feet NGVD, all discharges out of WCA 3A would be reduced by 15 percent.

2.17 Modified Minimum Delivery Operational Strategy (MMD). This operation was developed for use with the Minimum Structural Plan as an alternative approach for avoiding adverse modification of the snail kite Critical Habitat in WCA 3A. The intent was to make no changes in water management of WCA 3A, thereby duplicating the base hydrological condition for that area. In accordance with this, the minimum water delivery schedule to the Park prescribed by P.L. 91-282 would be retained and S-333 would not be used to deliver water to NESRS. Only the structural features south of L-29 would be retained: removal of L-67 ext., construction of the residential flood

mitigation system, flood-protecting the Miccosukee Indian camp, the seepage-control pump station in the L-29 canal, and replacing S-334.

2.18 No-Action Alternative (Base Condition). There would be no structural modifications to the C&SF Project and no residential flood mitigation under the No-Action alternative. The Energy and Water Development Appropriation Act of 1992 (PL 102-107) authorized an extension of the current Experimental Water Delivery Program until the modifications to the C&SF system under the subject GDM is constructed and implemented. Although the Act was silent on the possibility, one interpretation could be that, if the GDM project is not constructed, operation of the C&SF System could continue indefinitely under the Experimental Program. Land acquisition in the East Everglades by DOI for the Park expansion is independent of this GDM, and, therefore, would proceed under the Corps' No-Action alternative.

2.19 Other Plans Considered. A Flow-Through Plan was modeled that called for all the existing and considered new structures between WCA 3A and 3B and across L-29 (S-12s, S-333, S-345s, S349s, and S-355s) to be left fully open at all times. The plan was also field-tested with the S-12s and S-333 for one year in 1984 under the Experimental Program. The plan was dropped from further consideration after it became apparent that it would severely overdrain WCA 3A, thereby compromising the water supply objectives of the area.

2.20 National Economic Development Plan. The project has an environmental purpose and largely environmental benefits. These intended benefits are, by definition, nonmonetary and therefore not subject to NED analysis. Any monetary benefits that may occur from the project are incidental to the operation of the project for its environmental purpose. The monetary benefits are substantially less than the project's monetary costs. Therefore, no economically justified plans (including an NED Plan) have been developed, and an NED Plan cannot be selected. The Corps is authorized to make an exception to its NED regulations by P.L. 101-229, which states that "Construction of project modifications ... are justified by the environmental benefits to be derived by the Everglades ecosystem in general and by the Park in particular and shall not require further economic justification."

2.21 Structural Plan Recommendation. The Full Structural Plan is recommended because the complete set of structural features will be required to restore the natural hydrological conditions within the Park. It is the consensus of the participating planning agencies that these structures provide the necessary water management flexibility to fully test any future operational strategy.

2.22 Operational Recommendation. Coordination with the participating planning agencies has indicated that none of the alternative operational strategies is satisfactory. The Park has concluded that none of the considered operations "adequately reach" its restoration goals for the SRS Basin. The USFWS has determined that the BRD operation would jeopardize the endangered snail kite. The Florida Game and Fresh Water Fish Commission (FGFWFC) has objected to the use of WCA 3B in the two rain-driven operations until water quality issues are resolved. In the face of this lack of

consensus, the Corps proposes to work with the Park, the wildlife agencies, and the SFWMD over the next several years to develop an acceptable operational strategy with which to begin field-testing when construction is completed in 1997. This will lead into a long-term iterative field testing program with ecological monitoring by the Park and others to determine the best water delivery operation for restoration. If no consensus is reached, the MRD operation would be selected to begin the program because it is the only alternative applicable to the Full Structural Plan that does not conflict with the Endangered Species Act. Although the MMD Operation provides more fish and wildlife benefits based on wildlife modeling (see Table 7), it does not apply to the recommended Full Structural Plan and is, therefore, not acceptable to the Park or the SFWMD because it does not restore the historical path of water flow through the Everglades that is believed necessary for ecosystem restoration.

2.23 Ecological Monitoring. The key to developing the best possible water delivery operation for restoration of the Park is a long-term program of monitoring ecological responses in the Everglades to changes in water management. The Park's commitment to such a program within the Park boundaries is outlined in their letter of March 6, 1990 (Main Report Appendix A). The program needs to be regionalized to include, at a minimum; WCA 3 and Big Cypress National Preserve. Ecological information has been gathered in these areas for the past five years through the Systematic Reconnaissance Flights study by the SFWMD and FGFWFC, respectively. A commitment will be sought from these agencies to continue their funding and involvement in the regional effort. The SFWMD will be responsible for the monitoring in WCA 3. This will be addressed in the Local Cooperation Agreement (LCA) which will define the SFWMD's responsibilities as local sponsor for implementation of the project. Because extensive interagency integration will be required to implement an adequate regional monitoring program, additional coordination and planning with a wide range of interested parties will be conducted in the near future. If at the end of this process, deficiencies in the proposed monitoring program are identified, the Corps will pursue necessary supplemental funding for additional studies.

2.24 Comparative Impacts of Alternatives. Structural features of alternative plans are presented in Table 1, features of the alternative operational strategies are compared in Table 2, and Table 3 provides a comparative summary of the major effects of the operating alternatives.

3.00 AFFECTED ENVIRONMENT

3.01 The Study Area. The primary study area is the Shark River Slough (SRS) basin of Everglades National Park, including the portion of the slough that lies within the expanded Park boundaries. The northwest portion of SRS in the Park south of the S-12 structures is referred to as the Chimney. The portion of SRS east of the Park Chimney is referred to as Northeast Shark River Slough (NESRS). The latter is in part of the East Everglades, encompassing the area south of L-29, east of the L-67 extension, and west of L-31N. The Taylor Slough basin in the Park lies immediately south of NESRS and is hydrologically connected to it only during high water conditions. Water Conservation Area No. 3 (WCA 3) lies immediately north of SRS and is partitioned into WCA 3A on the west and WCA 3B on the east. Historically, SRS extended through WCA 3, but since the WCA is an impoundment without free passage of water except through structures, SRS is no longer identified as existing north of the Tamiami Trail.

HYDROLOGIC CONDITIONS

3.02 General hydrology. Local rainfall is the source of all of south Florida's freshwater. There are no rivers bringing water from afar, or any useable deep aquifer originating from distant recharge areas. The surface water that is not removed from the land by evapotranspiration and seepage to the underlying aquifer is drained to the ocean rather quickly through manmade canals or by very slow, shallow sheetflow through wetlands. The extreme flatness of the land results in a proportionally large increment of area inundation and a proportionally small increase in depths when an additional volume of water enters the area through rainfall or surface water management practices.

3.03 Surface Water Flow. The Everglades represent the path of surface water flow in the study area. It is a very broad (8-17 miles depending upon season), shallow natural drainageway at a slightly lower elevation than the surrounding land. Historically it was the principal pathway of water draining slowly southward from Lake Okeechobee to tidewater. Shark River Slough (SRS) is the southern constricted portion of the Everglades lying within the Park. In order of contributing magnitude, the three major sources of surface water to SRS in the Park during a normal meteorological year are: (1) in-situ rainfall, (2) regulated discharge of water from WCA 3A through the S-12s, and (3) seepage under L-29 from WCA 3B into the Tamiami Canal and thence through culverts into NESRS. An average annual rainfall of 57.9 inches contributes in situ about 2.5 million acre-feet of water to the SRS Basin of the Park. Water delivered to the Park through the S-12 structures over the period 1971 to 1982 represents a volume of about 16 percent of average annual rainfall. Historically, the surface water flowing south from the northern Everglades entered what is now the Park in greatest volume near the end of the rainy season due to the lag effect caused by slow sheet flow across marshes. This resulted in prolonged hydroperiods well into the dry season. The amount of seepage from WCA 3B into NESRS for the above period is about 2 percent of the rainfall input.

3.04. The Biscayne Aquifer. The most important component of the groundwater system within the study area is the Biscayne Aquifer. It is a highly permeable, wedge-shaped limestone formation underlying most of Dade and Broward counties with a maximum thickness of about 200 feet along the coast, thinning to a feather edge 35 to 40 miles inland. Where there is no impermeable formation above the aquifer, surface water recharges the system and the groundwater level can rise freely. In times of heavy rainfall the aquifer fills up and the water table rises above the land surface, contributing to seasonal inundation patterns throughout the area. Over much of its extent, the aquifer is covered by only a few inches of soil; in the Rocky Glades area of East Everglades (near Chekika State Park) the rock emerging at the land surface is the upper surface of the aquifer. Surface water filtering down directly into the aquifer rapidly recharges the system as it flows downgradient through the rock formations to the ocean. An exception to this may occur in NESRS. In the TBI Report (see paragraph 4.03), Dr. Durbin Tabb states his belief that the SRS basin is lined with virtually impervious marl "caulking", and that there would be free hydrologic connection with that part of the Biscayne Aquifer lying to the east of SRS only when water levels in the Slough rise higher than the elevation of the basin edges. This basin-edge elevation is taken to be 6.0 feet NGVD. Below that elevation, water will tend to remain in the basin; above about 6.0 feet the basin will overflow into the porous rocks to the east and set up a southeasterly groundwater flow to tidewater. The higher the water level rises over the basin peatlands, the stronger the sub-surface hydrologic connection to the southeast. In the absence of rain, however, when the water level in NESRS falls below about 6.0 feet, Biscayne Aquifer recharge by surface inflow is severed and the aquifer water levels under the coastal ridge decline at a rate of between 1.0 and 1.6 feet per month due to evapotranspiration and gravity drainage, unless off-set by canal delivery. On the basis of this, Dr. Tabb believes that the marl-lined SRS Basin is a poor recharge area for the aquifer when water is at elevations below 6 feet, but that it is uniquely situated to hold and deliver high quality marsh surface water, not only to the Park but to the ridge portion of the Biscayne Aquifer as well, when water levels exceed 6 feet. The aquifer provides water for all municipal water supply systems from Palm Beach southward, and for agricultural irrigation in Dade and Broward counties. Because of its importance to these systems and its vulnerability to pollution, the Biscayne Aquifer has been designated a "sole source" aquifer by the U.S. Environmental Protection Agency.

3.05. Water Quality. The quality of water delivered to the Park is frequently influenced by urban and agricultural activities elsewhere in the watershed. Of particular concern are floodwaters released to the south into WCA 3A from the Everglades Agricultural Area (EAA), which lies between Lake Okeechobee and the WCAs. Since the Everglades evolved in a nutrient-poor environment, the release of nutrients, particularly phosphorus, from the EAA has had a significant effect on sawgrass and wet prairie habitat. Large acreages of sawgrass surrounding the inflow structures in WCAs 1 and 2 have been converted to cattail. Historically, cattail has occurred in the Everglades as scattered patches related to some disturbance event such as drainage, canal construction, fire, etc. Large-scale cattail monocultures were not an historical feature of the Everglades. Lower in the WCA system, particularly in the southern portion of WCA 3A and in SRS, there is as yet

very little conversion to cattail. This is thought to be the result of the removal of nutrients by vegetation upstream. Water delivered to the S-12s through sheet flow over WCA 3A shows phosphorus levels of less than 10 parts per billion (ppb) total phosphorus. Water delivered through the L-67A canal during droughts frequently exceeds 30 ppb. The concentration at which phosphorus begins to cause changes in the natural Everglades vegetation is thought to be about 10 ppb. Agricultural runoff from the EAA is one of the issues in a lawsuit (United States of America v. SFWMD, et al.) alleging that the State has failed to enforce its water quality regulations. The SFWMD has completed a Surface Water Improvement and Management Plan (SWIM Plan) for the Everglades. This plan proposes action to substantially reduce nutrient loading to the WCAs and the Park within five years of implementation. Accomplishment of SWIM Plan goals should effectively remove the threat to the Park posed by phosphorus loading from the EAA.

WATER MANAGEMENT PRACTICES

3.06 Water management facilities affecting the study area consist of canals, levees, structures (gated and ungated), pumps, and water impoundments. Completion of the Tamiami Trail (U.S. Highway 41) and its attendant borrow canal circa 1929 resulted in the interception of overland flow of water through Shark River Slough into what is now the Park, but did not materially affect the flow-through characteristics of the system because the road bed was well culverted. In the late 1950's, a 585,000-acre water impoundment area (WCA 3) was completed immediately north of U.S. 41 to enable water to be stored for use during droughts and to prevent flooding during storms. Four gated structures (S-12A, B, C, and D), each with a design discharge of 8,000 cfs were constructed through the southern confining levee (L-29) of WCA 3 to enable water to be delivered to the Chimney of the Park. WCA 3 was split into two areas (WCAs 3A and 3B) in 1962 by an intervening levee system (L-67A & B) to isolate the excessive seepage out of the eastern portion. One of these levees was extended to the south for 9.5 miles (L-67 Ext) in order to prevent water from flooding east over private lands during periods of high discharge into the Park through the S-12 structures, and to facilitate movement of water to the south via the adjacent canal. In 1978, the L-31N borrow canal was enlarged to augment existing conveyance for water supply purposes. This became part of the canal network now known as the Everglades National Park/South Dade County Conveyance System. Part of this increased conveyance was needed to implement annual delivery of the Congressionally mandated 37,000 acre-feet of water to the Park at Taylor Slough. This is accomplished by means of pump station S-331 in the L-31N canal and pump station S-332 located on a spur canal and levee (L-31W) from L-31N. These facilities went into full operation in 1983. In August 1982, the SFWMD installed a structure consisting of three 72-inch gated culverts (G-130) through L-29 just east of the junction with L-28. These have a design capacity to discharge about 250 cfs from WCA 3A into the Tamiami Canal. With the downstream structure (S-14) in the canal normally closed, the water would pass through culverts under U.S. 41 and spread out into Big Cypress National Preserve. The purpose of this work was to help lower high water levels in WCA 3A when they stress the deer population.

3.07 Water Deliveries to the Park. By the River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970 (PL 91-282), Congress established a minimum schedule of water volumes to be delivered to Everglades National Park. Most of the water is delivered to Shark River Slough through the four S-12 structures. Minimum delivery to SRS was set at 260,000 acre-feet annually, to be distributed monthly as shown in Table 4. In times of water shortage, the Act allows deliveries to be cut back to a volume representing 16 1/2 percent of the total volumes released from the Central and South Florida project. From 1971 through 1982, the Park received an average of about 392,000 acre-feet of water per year with a range from 565,000 in 1978 to 239,000 in 1971 (PL 91-282 was implemented in June 1970). During the previous five years (a series of wet years), the annual average was 1,040,000 acre-feet. Actual water volumes received by the Park through Shark River Slough are determined by Federal regulations, physical capabilities of the system, and management decisions of the Corps of Engineers, the South Florida Water Management District (SFWMD), and the Park. The principal governing factor is the stage (height) of water in WCA 3A (see paragraph 3.09). In addition to the 260,000 acre-feet deliveries discussed above, the Act provides for 55,000 acre-feet per year to be delivered across the eastern boundary of the Park at two locations. Thirty-seven thousand acre-feet of water are to be delivered into the headwaters of the second major slough in the Park (Taylor Slough) through a pumping station (S-332) situated on the L-31W canal (Plate 1). At the second location in the southeast saline Everglades region of the Park (the eastern panhandle), 18,000 acre-feet of water per year is mandated to be delivered by spill-over from C-111 through gaps in the adjacent levee. Water for the above is brought to the delivery locations through the Everglades National Park/South Dade County Conveyance System, a network of canals and levees radiating east and south from the Tamiami Canal.

3.08 Experimental Program of Water Deliveries to the Park. In response to the Park's "7-point plan" of March 1983 and with authorization from Congress contained in PL 98-181, the Corps initiated an experimental plan of water deliveries to the Park in June 1985 which has continued to the present. The operational plan, developed by the SFWMD, involves the timing and volume of water deliveries based on rainfall events, and is called the Restricted Rain-Driven Delivery Plan. It makes use of the S-12s and S-333 to spread water across SRS, but, as a result of litigation, it is restricted during high water conditions to avoid the potential of adversely impacting the residential and agricultural areas in the East Everglades. The delivery volume calculation is the same as described in the BRD Operational Strategy. The Park has indicated that they would like this delivery plan to stay in effect until superseded by the operation that will be implemented when the recommended structures are ready for use. New Congressional authority will be required for this program effective January 1, 1992.

3.09 Water Management of WCA 3A. In order to maintain sufficient water storage capability in WCA 3A for flood control and other purposes, the Corps manages water releases to keep the stage from exceeding a defined stage regulation schedule which varies from 9.5 feet to 10.5 feet NGVD, depending upon the time of year. The prevailing meteorological conditions within the basin have a major bearing on how close water levels stay to the regulation schedule. When water delivered to the Park under the 260,000 acre-feet per

year Minimum Delivery Schedule is not sufficient to keep WCA 3A from going above its regulation schedule, additional "flood" releases are made to lower the stage. Water can be released from WCA 3A at four locations: (1) into WCA 3B through S-151 near the top of L-67, (2) east through the Tamiami Canal by opening S-333 and S-334, (3) south into the Park through the S-12 structures (usually in conjunction with closing S-333), and (4) south into Big Cypress National Preserve via structure G-130 through L-29. Historically, the major site of flood release has been the S-12 structures because they have the greatest capacity. The WCA 3A regulation schedule provides a flood-control ceiling for water stage; there is no officially defined floor, although an "environmental floor" of 7.5 feet NGVD is observed when possible. The Park delivery schedule for Shark River Slough has been treated as a minimum. However, operating practice has been to provide monthly deliveries as close to delivery schedule as possible, without deficit, whenever water in WCA 3A is below regulation schedule. This is done to maintain sufficient storage in WCA 3A in order to ensure available water for subsequent Park minimum deliveries and to satisfy other purposes of the project, such as storage for wildlife conservation and aquifer recharge.

3.10 Flood Releases into the Park. Average annual discharge of water into the Park through the S-12 structures for the period January 1971 through December 1982 was about 392,000 acre-feet or 51 percent above the 260,000 acre-feet Minimum Delivery Schedule. The extra water was almost entirely a result of flood releases from WCA 3A made in order to keep the stage within the regulation schedule; 5 to 10 percent excess is delivered to ensure that the minimum is met. Most of the excess water was released during the months of July through October. The greatest release as a percentage of the delivery schedule occurred during the period March through August (Table 4).

HYDRIC SOILS

3.11. Peat Soils. Peats of the Everglades (Loxahatchee and Everglades Sawgrass Peats) can form and persist only under conditions of permanent flooding and/or saturated soil conditions. Peats form from decaying vegetation, which accumulates at an estimated rate of 3 inches per century, and in turn support the continued growth of the plants. The process is dependent upon a superabundance of water, usually free water above the surface of the soils. Aquatic plants and some marsh plants have above-ground parts that quickly wilt and perhaps die when the water level recedes below the surface. However, in the Everglades peats most aquatic plants can still obtain sufficient water even after the percent of soil water is less than a third of the average.

3.12 Marl Soils. Marls are also accumulating soils under normal hydrological regimes of the region. Marls of the Everglades (Perrine and Ochopee), unlike peats, form only under seasonal, shallow, surface flooding conditions, and only in areas adjacent to large exposures of soft limestones, such as Miami Oolite (TBI Report - EIS Appendix B). Groundwater passing through these formations becomes charged with calcium carbonate in solution, which is then re-precipitated by blue-green algae as marl, in an association called periphyton. Buildup of organic remains in the marl-producing areas is inhibited or prevented by regular dry-season oxidation in areas of relatively

short hydroperiod (5-7 months), but organic content in the form of algal biomass appears to increase in the deeper, long-hydroperiod periphyton areas. Marl has accumulated at a rate of about 1/2 inch per century during the recent geological history of the region.

EVERGLADES VEGETATION

3.13 Macrophyte Communities. The historical wetland communities of the southern Everglades included sawgrass marshes, sloughs (with aquatic plants), marsh (marl) prairies, tree islands with bay forests, and cypress forests. Upland communities included Miami rockland pine forests and hammock forests, both in the pinelands and as tree islands surrounded by wetland vegetation. A gradient of water conditions and associated hydroperiods exists among these communities. The hammocks and pinelands are the driest communities. The marl prairies have intermediate amounts of flooding, averaging 6-8 months with depths up to 1 foot. The swamp forests and dense sawgrass stands have slightly longer hydroperiods and deeper water. The slough communities are the wettest sites, with almost continuous inundation. Quantification of hydroperiods within these communities is difficult because of the high annual variation. The communities are established in response to a number of factors in addition to hydroperiod, such as soil characteristics, fire and seed dispersal, and germination requirements. Once established, the communities seem tolerant of a wide range of hydrological conditions. However, changes can occur from alteration of the hydrology, with direct effects due to prolonged flooding or droughts, and indirect effects that are associated with an altered fire regime. Most of the historic wetland communities exist at present, although changes have occurred in the species composition, structure, and spatial distribution of some communities as a result of altered water conditions.

3.14 Exotic Plants. Historically, exotic (non-native) plants were probably not present to any appreciable extent in the Everglades. At the present time, several exotic plant species have become a problem or potential problem in parts of the Park and surrounding areas. Water hyacinth occurs in canals, but so far has been unsuccessful in invading native marshes. The principal threat is posed by three woody exotic species: Australian pine, melaleuca, and Brazilian pepper. Australian pine and melaleuca have become established in several areas in and around the Park, and have moved rapidly westward across NESRS to within a mile of the original northeast border of the Park, spread by wind and water. Brazilian pepper is a problem in pinelands, hammocks, tree islands, and abandoned farm fields, spread primarily by birds. While these species invade a variety of natural vegetation communities, their spread in wetlands is attribute primarily to the decline in vigor and health of the natural communities , mostly associated with reductions in hydroperiod and water depths.

3.15 Periphyton consists of an assemblage of green and blue-green algae and diatoms in a matrix of marl that forms thick mats blanketing the marsh surface in areas of the Everglades that are underlain with soft limestone with a seasonal surface water regime of 3-10 inches in depth. Periphyton play a very important ecological role in primary productivity, soil building, dissolved oxygen maintenance, and as food and habitat for a wide range of

aquatic fauna. In historic times, a much wider area of the Everglades was inundated over longer periods of time on a seasonal basis as compared with present day conditions. Periphyton mats today cover a much smaller area of the lower Everglades, and support a much reduced community of forage organisms. Shortened hydroperiods, reduced soil organic matter, and nutrient-enrichment of marsh surface water have adversely impacted the structure and function of Everglades periphyton communities. This has reduced secondary productivity and diversity in the aquatic animal community.

3.16 Fire in Vegetative Communities. Historically, fire has been a naturally occurring phenomenon that played an important role in establishing and maintaining certain fire-dependent Everglades plant communities. Natural fires were associated with lightning, primarily during the wet season. Under the present conditions, there has been an increase in damaging dry-season fires resulting from accidental and deliberate ignitions by man. These fires kill plants that are otherwise naturally fire-dependent, consume the upper layer of organic soils, critically alter the surface topography, and release excess nutrients. Most importantly, dry season fires have promoted the spread, establishment, and eventual dominance of woody exotic plants in many natural communities in the Everglades: Brazilian pepper on tree islands and melaleuca in marshes and on tree islands. The regionally lowered water table has lengthened and intensified the dry season effects on wetlands, permitting even more destruction by these fires. In recent years, incendiary dry-season fires have destroyed or damaged numerous tree islands, pinelands, and organic-soil wetlands in the Park and adjacent areas. Many of the Park fires have entered from NESRS where unnaturally dry conditions have allowed fires to spread rapidly across broad fronts.

EVERGLADES WILDLIFE

3.17 Faunal Species Abundance. The Everglades provide habitat for about 25 terrestrial species and two aquatic species of mammals. The avian fauna of the Everglades is especially rich; over 300 species of birds have been identified in the Park. South Florida's location makes it a migratory crossroads for West Indian and Central and South American birds; numerous North American species are residents. The majority of this continent's species of wading birds, shorebirds, and waterfowl are found here at some time of the year. One of the key reasons for the establishment of the Park was to protect the nesting areas and feeding grounds of wading birds such as herons, egrets, and ibis. The known herptiles of the region include 2 species of crocodilians, 3 or 4 species of salamanders, 6 species of lizards, 10 species of land and freshwater turtles, 5 species of sea turtles, 12 species of frogs, and 23 species of snakes. The waters of the Everglades and the Park support a large variety of fish in both freshwater and estuarine habitats. Fish provide a major part of the diet of most of the other vertebrate animal inhabitants. The following paragraphs discuss in detail the historic and existing conditions of species or groups of species of particular importance for their ecological role in the Everglades or as bioindicators of overall ecosystem health.

3.18 Historical Freshwater Fish Communities. Ecologically, fish are important as a food resource for higher level organisms, particularly wading

birds. The historic condition of the fish community is not known, but can be deduced from the known relationship between fish population dynamics and hydrology. The Everglades freshwater fish community responds to different sets of water conditions through changes in species composition, biomass, and size structure. Population densities and biomass are greatest in marshes with seasonally fluctuating water depths and extended hydroperiods. In the Everglades, recruitment of young fish into the population reaches a peak in late summer and fall, and declines through the winter. By February or March, reproduction begins again and, combined with the concentrating effect of receding water levels during the dry season, densities subsequently reach high levels. The availability of these high densities of fish and macroinvertebrates is essential for the full utilization of this food resource that is required for successful nesting by wading birds. Historical records of successful nesting by wading birds in the Everglades indicate that historically there was a large biomass of fishes and macroinvertebrates produced in the Everglades which became available to wading birds during the nesting season as a result of appropriate hydrological conditions.

3.19 Existing Freshwater Fish Communities. Sampling of aquatic animals by the Park in NESRS showed that densities were about 30% lower than those within the SRS marshes in the Park. This is attributed to the long-term reduction of hydroperiods in NESRS marshes since 1962, which also has resulted in the deposition of a layer of marl on top of the original peat substrate. Marl deposition is indicative of a shift in the species dominance of the periphyton community from green algae and diatoms to blue-green algae. This may have contributed to the lowered secondary productivity because laboratory feeding studies have shown that fish and invertebrate grazers select against blue-green algae in favor of the other species.

3.20 Historic Wading Bird Populations. The best historical numerical data for wading birds in the southern Everglades are for wood storks. The stork nesting colonies in the 1930s are estimated to have contained between about 2000 to 4000 nests in most years. From that decade until 1960, the stork nesting effort in the Park declined slowly to about 2400 nests on average (range 600-3000), apparently in response to the gradual loss of wetlands to development in the southern Everglades. The rate of successful nesting was relatively high compared with recent years, with large numbers of young storks being produced in 6 out of 7 years during the 1940s, and in 5 out of 10 years in the 1950s. Considerably less precise historical data up to 1960 are available on population sizes and trends for the other principal species of wading birds of the interior Everglades: egrets, herons, and white ibis. A single mixed-species colony at Rookery Branch in the lower SRS in 1934 was estimated to contain between 110,000 to 225,000 nests. The same colony in 1940 was estimated to contain 60,000 nests. By 1960, the total breeding effort for all wading birds in the Everglades was estimated at 150,000 nests. The next two decades were characterized by dysfunctional changes in historic nesting behavior of wading birds. Initiation of nesting by wood storks gradually shifted from the historic November/December period to January-March. During the 1970s, late nesting by wood storks became routine, as did nest failures. Because of late nest formation, colonies were often still active with nestlings when rains began in May/June. With rising water levels, adults were unable to collect enough food, and young were abandoned to die in their

nests. The rate of population decline for wood storks accelerated sharply during the 1970s, with a mean annual breeding effort of 875 nests (range 290-1235). Population trends for the other wading bird species during these two decades closely followed the pattern shown by storks, with an estimated breeding effort in 1974/75 in the Everglades of 48,000 nests (11,000 of which were in the Park). By the mid-1970s, these species had abandoned the traditional colony sites near the coast in the Park and shifted to new sites in WCA 3A, apparently in response to the ponded area in the southeast corner. This shift is believed to increase the chances of nest failure because WCA 3A does not have as great a heterogeneity of forage sites as do the traditional colony sites within the Park, leading to less opportunity for the birds to find sufficient food over as wide a range of meteorological conditions. WCA 3A may also be less suitable for nesting wading birds because of a relatively high frequency of unseasonable water level fluctuations caused by water management practices for other project purposes.

3.21 Existing Wading Bird Populations. Between the late 1970s and present, wood storks and other wading birds experienced the most rapid rate of decline of any decade in south Florida history. The average annual breeding effort in the Park was 375 nests (range 15-1660). The population reduction during the three decades since 1960 has been 80%. Total mainland (excluding Florida Bay) breeding populations of other wading bird species also reached extreme lows during the 1980s. In 1986 and 1987, there were about 8300 and 10,400 nest starts, respectively, by all species of wading birds in the Park and WCA 3. This was less than one fourth the number estimated during the last comprehensive survey of the same area in the mid-1970s, and at least an order of magnitude less than nesting numbers during the period 1940-1960. Wood storks and white ibis showed the greatest reduction, and Great egrets the least. Only about 11% of the wintering population of wading birds stayed to nest, and there were substantial numbers of most species that were present during the nesting season, but did not breed. The breeding results in 1986 and 1987 are attributed to excessively slow water drying rates leading to poor feeding conditions, few nesting attempts, and late nesting failures. An insufficient drying rate and/or reversals in falling water levels during the dry season is believed to have been a pervasive problem for wading birds since implementation of intensive water management in the southern Everglades. This is probably interrelated to a decrease in forage fish populations in areas with unnatural hydropatterns such as NESRS.

3.22 Alligator Populations. The historical alligator population in the Everglades south of Tamiami Trail is estimated to have been as large as 1,000,000 animals, based on the number of gator holes present in the area. By the mid-1960s, it was estimated that the population had been reduced to 10 to 20% of the pre-settlement number as a result of hunting, poaching, and human alteration of water conditions in the area. With the return of surface water discharge into the Park and protection under the Endangered Species Act in 1973, the population began to increase again. However, at present the alligator is almost completely excluded from NESRS because of unsatisfactory water conditions there. The major problem facing the alligator in SRS since scheduled water deliveries to the Park began in 1971 is excessive nest flooding from untimely release of flood waters out of WCA 3A in late summer.

ENDANGERED SPECIES

3.23 Listed Species Present. The term "endangered species" means any species that is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is one that is likely to become endangered within the foreseeable future. Coordination with the U.S. Fish and Wildlife Service has indicated that the study area is included in the range of 16 species of animals Federally listed as threatened or endangered under the Endangered Species Act (Table 5). The American crocodile and Cape Sable seaside sparrow are endemics in South Florida. The peregrine falcon occurs sporadically during the winter and in migration. The remaining species breed or potentially breed within or immediately adjacent to the study area.

3.24 Critical Habitat. Critical Habitat is defined as the specific areas within or outside the geographic range occupied by the species, at the time it is listed under provisions of the Act, in which are found those physical or biological features that are essential to the conservation of the species and which may require special management considerations or protection. Designated Critical Habitats that lie within the study area are as follows. Cape Sable seaside sparrow: muhly prairie areas in the Park and the East Everglades; Snail kite: all of WCA 3A and portions of Shark River Slough within the chimney of the Park; American crocodile: coastal areas along Florida Bay extending inland along canals (especially C-111) and rivers; Manatee: coastal areas surrounding the Park.

SOCIO-ECONOMIC SETTING

3.25 Private Lands. Within the EIS study area, the only non-public land lies within the East Everglades, which is primarily in private ownership. Most of this land, however, is uninhabited. Under provisions of the Everglades National Park Protection and Expansion Act (P.L. 101-229), about 107,600 acres of these lands will be incorporated into the Park through purchase by the Department of Interior or donation by the State.

3.26 Residential and commercial development in the East Everglades is concentrated in the 8-1/2 sq. mi. area that is recommended to be leveed off from the remainder of the slough. This is a narrow tract of land located about 10 miles south of the Tamiami trail, parallel with and extending several miles west of L-31N. In this area there are 230 permanent homes (including 60 mobile homes) serving as residences for farmers, local business people, and commuters to Miami. The total resident population is estimated at 460 individuals. Outside this area are four permanent residences within about two miles west of the levee alignment and a small number of hunting camps scattered among the many tree islands within NESRS. Commercial development in the East Everglades consists of several nurseries, a kennel, a fruit packing house, and a rabbit farm. On the Tamiami Trail there is a commercial airboat operation, a gas station, a restaurant, souvenir shops, and the Indian camps discussed below.

3.27 Tiger Tail Indian Camp. This Miccosukee Indian camp, located along the Tamiami Trail about half way between L-30 and L-67, has been built on flat ground between L-29 and the Tamiami Canal. The camp represents an extended

family grouping made up of about 20 individuals in five families. Structures in the camp include traditional Indian dwellings called chickees and conventional wood frame buildings (Plate 33). The camp is not situated on tribal lands, but the tribe asserts that the Indians who occupy the camp do so under an aboriginal right to the lands. County records show that title to the land on which the camp is built lies with the Florida Trustees of the Internal Improvement Fund. The camp is also encompassed within an easement for the Tamiami Canal owned by the SFWMD. The Indians operate airboat businesses and crafts stores, work in nearby businesses and farms, and hunt frogs for sale and subsistence.

3.28 Osceola Indian Camp. The second Indian camp is located on the south side of the Tamiami Trail just east of L-67 Ext. on lands intended for acquisition by DOI under the Everglades Protection and Expansion Act. The camp occupies about 1-1/2 acres and consists mostly of traditional chickee and modified chickee structures, including a public store (Plate 34). The site is home to two families made up of about five individuals.

3.29 Flooding. In the early 1950s, the first 15 miles of L-31N was constructed to provide flood protection for the adjacent urban areas to the east during periods of high water in NESRS. Since that time, particularly during the drought of the early 1960s, residential development spread west of the levee and consequently has suffered flooding on a number of occasions, most notably in August 1981. Flooding effects primarily involve roads, since most homes and septic systems are built up on fill. The Federal Emergency Management Agency shows the entire study area to be within the 100-year flood plain, although no flood elevations have been developed.

3.30 Prime and Unique Farmland. Agriculture is a principal aspect of the developed portion of the East Everglades. There are about 5,000 acres of land under cultivation within and adjacent to the previously described residential area paralleling L-31N. In order of total acreage planted, the primary agricultural activities are winter vegetables (e.g., tomatoes, squash), tropical vegetables, tropical fruits, citrus, and ornamentals. Although farmers indicate that this land is not optimal for growing vegetables, it is considered unique farmland under USDA Soil Conservation Service definitions because it is in a frost-free climate permitting the production of winter crops.

3.31 Hazardous Toxic Wastes. A reconnaissance level survey of the residential area levee and conveyance canal alignments has been made for signs of hazardous toxic wastes (HTW). Considerable commercial and residential debris was found along both sides of 121st Street, consisting of 55 gallon drums, various size cans, automobile parts, household appliances, etc. There was no evidence from sight or smell that any HTWs were associated with this debris.

RECREATION

3.32 General. The principal recreational resource within the study area is the Park. There are numerous sites available within the Park for natural history observations along interpretive trails. At Flamingo, there are also

facilities for boating, fishing, and camping adjacent to Florida Bay. Chekika State Park, situated on Grossman Hammock in the East Everglades, has camping, picnicking, and interpretive nature facilities. Most of NESRS is used for recreational activities such as airboating, hunting, and fishing (along the canals). The Kendall Gliderport near the State Park provides opportunity for soaring and skydiving.

3.33 Fishing. The L-67 canals are considered an outstanding regional resource by recreational fishing enthusiasts. The L-67A canal is reported to be the most productive and heavily used bass-fishing grounds south of Lake Okeechobee. A 6-month Angler Use Survey (AUS) of 1451 anglers in the L-67A Canal conducted by the FGFWFC from December 1990 to June 1991 showed a total fishing effort of 50,000 man-hours and a total catch of 51,000 fish (see FGFWFC letter of August 29, 1991 in Main Report Appendix A). Sportfishing tournaments are often held on weekends out of Everglades Holiday Park located at the northern end of the L-67A Canal adjacent to the S-9 pump station. This facility is owned by the FGFWFC and provides refreshments, fishing supplies, boat rentals, guide services, and four boat ramp lanes. It is a popular tour bus stop for sight-seeing rides on air boats. The State and County recently spent over $200,000 on upgrading the boat ramps and fishing docks, and the current lessee, Mr. Mitchell Bridges, contributed $5000 to improving the parking facilities. Typically, the bass boats proceed south down the large L-67A canal at high speed to particular fishing spots. The full length of the canal is used by the anglers to spread out and make best use of the resource. The AUS showed that about 71% of the anglers in the L-67A Canal launch from the north end, and of these, 33% fish in the south half of the canal. There is a one-lane boat ramp provided by the FGFWFC with no other facilities at the southern end of the canal near S-333 for those who can bring boats in by trailer. There is a similar facility nearby in the L-67C Canal, the only such access available. Fishing is also very good in this canal, but it appears to be less heavily used, perhaps because it is smaller and less accessible. Sportfishing tournaments are sometimes held at this southern location so fishermen can choose either of the canals. During the AUS, about 50% of the anglers who launched from the south end had fished in the L-67C Canal. The other 50% fished in the southern half of the L-67A Canal, rarely boating north into the upper half. Most fishermen practice catch-and-release fishing to conserve the resource and because of the publicized cautions about mercury contamination of fish throughout the Everglades.

CULTURAL RESOURCES

3.34 Prehistoric Conditions. The study area contains many sites of prehistorical value. Aboriginal habitation and use of the area dates back to 500 A.D. The Tequesta Indians inhabited much of southeastern Florida, including the Everglades, until the seventeenth century when diseases brought by Spanish explorers severely reduced their population. The Seminoles inhabited the area during the eighteenth and nineteenth centuries, but were driven out of the Everglades to southwest Florida as a result of the Seminole Wars in the mid-1800's.

3.35 Historical Sites. Historical use of the Everglades by aboriginal peoples is evidenced primarily by black earth middens and burial grounds, both

usually located on high ground such as tree-islands. The middens were typically seasonal camps used by small bands of people in foraging for wildlife and growing food crops. Exploration of these areas typically reveals residual debris such as pottery and tools. Many bayheads and hardwood hammocks in SRS contain middens and burial grounds, and these tree islands also have potential value as historical sites. For example, the site of Fort Henry, the Army supply depot in the Everglades during the Seminole wars, is located in the East Everglades. Approximately 10 sites located in the East Everglades are now included on the State of Florida Archives Master Site File and many more lie within the Park. Although there are presently no sites listed on the National Register of Historic Places, it is expected that several archeological sites in the East Everglades would be eligible for listing.

4.00 ENVIRONMENTAL EFFECTS OF ALTERNATIVES

4.01 Summary. Construction of the recommended structural features necessary for managing water deliveries to the Park will require dredging and filling in project area wetlands. As a result, a net immediate loss of 173 acres of wetlands will be incurred. The loss will be more than compensated for by the enhancement of NESRS and Park wetlands that will result from operation of the project for restoration of natural hydrological conditions. Blasting required in conjunction with dredging conveyance and collector canals through rock strata will have short-term disruptive effects on the behavior of birds and mammals within close hearing range of the construction. Although a recommendation for an operational strategy has been deferred for several years, several operations were evaluated, and their projected effects are presented in subsequent paragraphs.

SOURCES OF INFORMATION

4.02 General. There are three major sources for the analyses presented in the following paragraphs: a report by a consulting firm: Tropical BioIndustries, Inc. (TBI); a "White paper" developed by an ad hoc task force; and the Fish and Wildlife Coordination Act (FWCA) Report from the U.S. Department of Interior. With the exception of the "White Paper", all of the analyses were based on predictive hydrology from the South Florida Water Management Model developed by the South Florida Water Management District (SFWMD) and run by the Corps.

4.03 TBI Report. In 1984, the Corps contracted with TBI to make recommendations on the water conditions within the Park and NESRS that would optimize conditions for key ecological resources that are indicators of the overall "health" of the Park. The contract also called for an evaluation of the Corps' alternative plans in relation to the recommended water conditions. The Contractor's report by Dr. Durbin Tabb, is considered a technical background document for this EIS and will be made available for review upon request. The Executive Summary is included as EIS Appendix B.

4.04 "White Paper. In May 1987, a three-day invitational workshop was held in Homestead, Florida and attended by Federal, State, and local scientists who were or had been actively involved in research in the Everglades, or had institutional oversight responsibilities. The purpose was to develop a consensus on the potential environmental benefits to the Park of restoration, to the extent practicable, of natural hydrological conditions within Shark River Slough. The analysis was not based on modeling, nor was it specific to any plan. The "White Paper" is included as EIS Appendix C.

4.05 FWCA Report. Under provisions of the Fish and Wildlife Coordination Act (16 USC. 661, et. seq.), the Corps funded the USFWS to participate in the planning process for the GDM. They made recommendations and analyzed the alternative operating strategies for impacts on fish and wildlife resources, including endangered species. Hydrological and biological analyses submitted to the USFWS by the Park were, in part, incorporated. A preliminary draft of this Report was coordinated with the Florida Game and Fresh Water Fish Commission, the National Marine Fisheries Service, and the Park. The Park's

review comments were submitted as a separate report, in which they disagreed with the USFWS's wildlife analysis methodology, but came to similar numerical findings on wildlife benefits of the operational alternatives, with the exception of the snail kite. The Final FWCA Report covering the changes in the final recommended project (including the changes described in paragraph 2.04) is included in EIS Appendix D.

POTENTIAL HYDRO-BIOLOGICAL EFFECTS OF STRUCTURAL ALTERNATIVES

4.06 Minimum Structural Plan. The removal of the levee and canal bisecting the northern 10 miles of SRS would allow water deliveries discharged through the S-12 structures to spread southeast by gravity flow following the marsh topography. This would fully restore the hydrologic connection between the chimney and NESRS. However, the limiting capacity of S-333 for spreading regulatory flood releases directly into NESRS would still present an impediment to restoration of natural water conditions in the Park. The eastern slope of the Everglades Basin in NESRS would still have shortened hydroperiods resulting in lower than historic primary and secondary productivity. Ecological restoration in the expanded Park would be less than wit the recommended plan. Alligator nest-flooding south of the S-12s would be reduced in frequency, and the population would expand more into NESRS, its historic center of density. WCA 3B would not be brought back into the Everglades system. The lack of maximum opportunity to use the potential productivity from this 100,000 acres of Everglades habitat would still severely limit the ability of wading birds to make a reproductive recovery. Historically, WCA 3B was very important dry season feeding habitat for wading birds in the large nesting colonies in the Park. The periphyton-forage fish-wading bird food chain has virtually collapsed in this area since it has been impounded. Aquifer recharge and restoration of groundwater and surface water flows to coastal areas could not be maximized, nor could the degree of estuarine recovery.

4.07 Full Structural Plan- Biological. Conveyance of water from WCA 3A through WCA 3B would restore the historic flow patterns in the Everglades Basin. By so doing, 100,000 acres of prime Everglades habitat would be brought back as a fully functional component of the Everglades system. The surface water component added to direct rainfall effects in WCA 3B would recreate the hydrologic dynamics in the system that has been almost totally lost since the area was impounded. The additional volume would create a fluctuating water level with seasonally deeper water in the center of the historic slough in WCA 3B, and would restore the historic short hydroperiod in the marshes along the eastern edge. This would build up the food resource base of small fishes and macro-invertebrates for harvesting by wading birds during the dry season recession. The increased water levels and secondary productivity combined with the topographical heterogeneity of the area would create a seasonal diversity of feeding habitats. This would greatly increase the opportunities for wading birds to find forage sites under a wide range of water conditions. Ecological restoration of WCA 3B in addition to NESRS is believed to be the key to restoring long-term trends in successful nesting by wood storks and other wading birds in the Park because it historically played such an important role in sustaining the large nesting colonies during the dry season. Increased water depths would also benefit the apple snail, a food

resource for a wide array of animals, and the essential food source for the snail kite. Regional snail kite populations, therefore, would be expected to increase as the kites repopulated the area.

4.08 Full Structural Plan-Hydrological. Hydrologic restoration of WCA 3B is essential to restoration of natural water conditions in the Park. Diversion of flood waters from WCA 3A into detention in WCA 3B would decrease the volume of and, in some cases, the need for regulatory water releases into the Park from WCA 3A. This would reduce the frequency of unnatural distributions of water across SRS, and further reduce the occurrences of alligator nest flooding south of the S-12s. The ability to discharge an additional 2000 cfs of water into NESRS through the new S-355 structures as well as 1300 cfs through S-333 would allow full restoration of historic water depths in the center of the slough, thereby causing re-flooding of the short-hydroperiod marshes on the eastern slope of the basin. This would accrue all the wildlife benefits from increased primary and secondary productivity previously discussed. In addition, aquifer recharge, reestablishment of groundwater flows, surface water reconnection between SRS and Taylor slough, and restoration of estuarine productivity will all be maximized.

HYDROLOGICAL EFFECTS OF OPERATIONAL ALTERNATIVES

4.09 General. The following four paragraphs present ecologically relevant hydrological analyses of the operational alternatives prepared by the Park and included in the FWCA Report. Table 6 summarizes the results.

4.10 Effects on Moderation of Unseasonable Water Flows from Regulatory Releases from WCA 3A. The models of Base and MMD alternatives produced abrupt seasonal spikes of stage increases from regulatory water releases with rapid flow increases occurring each year between July and August, regardless of the timing of local rainfall. In contrast, modeled flows under the BRD and MRD alternatives showed a more gradual rise of water levels in response to the start of wet season rainfall (reduction in abrupt spikes), and the timing of these flows varied annually in response to the observed rainfall conditions. The impacts from sudden regulatory water releases were tempered by dissipating flooding across a broad front. The MMD Plan does this to a degree, allowing flows from the S-12's to run east toward NESRS. The MRD and BRD alternatives do this more directly by discharging directly into NESRS. The combination of a transition zone in the release schedule and redirection of flows strongly improves the performance of these two alternatives. In addition, they allowed the diversion of water from WCA 3A into detention in WCA 3B, thereby reducing the floodwater volume that had to be discharged out of WCA 3A with potential for ecological damage.

4.11 Effects on Redistribution of Water Flows Across the Full Width of SRS. The Park's objective of redistributing flows is best met by the MRD alternative. This alternative includes new structures to move water between WCA 3A and WCA 3B, and then directly into NESRS. The goal is a 55/45 percent split in the water delivered across the Tamiami Trail between NESRS and the Park's Chimney (south of S-12's), respectively.

4.12 Effects on Timing of Water Deliveries. The Park found that water deliveries had more natural timing under the MRD/BRD Plans. In the absence of large regulatory releases, flows under the Base and MMD alternatives consistently peaked in October and decreased at a fixed rate through January. In contrast, under the BRD and MRD alternatives, the timing of wet season peaks and length of the recession curves varied each year in response to the cessation of rainfall.

4.13 Effects on Hydropatterns. The Park examined patterns of flooding and hydroperiod, and interpreted these in four depth classes and five hydroperiod classes by season for each hydrologic year (June-May). In NESRS, all action alternatives showed an overall increase in water depths compared with the Base Condition. The MRD alternative was most effective at restoring deep-water conditions. In an average wet season, the deep-water class was increased by 29 percent. In dry years, the MRD/BRD alternatives produced a larger deep pool than the MMD alternative. The Park indicates that the MRD alternative is much more effective at maintaining a central core of deep water from NESRS to the downstream estuaries under these hydrologic conditions. In contrast, the Base and MMD alternatives produced nearly equal percentages of deep water, but these areas occurred in isolated pools. Under average dry season conditions, the MRD and MMD alternatives showed an overall decrease in water depths, compared to the Base. Under below-normal dry season conditions, the MRD and MMD alternatives substantially reduced the percentage of the basin that dried completely.

4.14 Inundation Effects. Figures in the FWCA Report show the percentage of the time that each hydrologic model cell was flooded by more than 2 inches of water during the 14-year period of record. The MMD Plan causes very minor changes in WCA 3A, some increase in flooding in WCA 3B, minor but extensive decrease in flooding in the Park and a significant increase in flooding in NESRS (locally, about an additional 10 to 30% of the time). The MRD Plan shows minor but extensive increases of flooding in WCA 3A, mixed effects in WCA 3B, reduction of flooding in the Park, and very sizeable increases of flooding in NESRS (locally, about an additional 15 to 50% of the time).

4.15 Biscayne Aquifer. An increase in elevation of surface water within the recharge areas of the Biscayne Aquifer would increase aquifer recharge, thereby providing water supply benefits to users. The increase in recharge has not been quantified, nor has an economic benefit been calculated. However, based on the conclusion in the TBI Report that NESRS is an impervious marl-lined basin up to elevation 6.0 feet NGVD, it is expected that re-flooding NESRS would restore considerable recharge, and the deeper the flooding, the greater the recharge. Hydrologic Model stage-excedance predictions at gauge NE-1 indicate that recharge under all three alternative operational plans would increase in frequency by an average of 15% (from 75% to 90% of the time). Based on water levels, the MRD alternative would provide the greatest volumetric recharge and the MMD alternative the least. It is estimated from the excedance curves, that the MRD alternative is better in recharge potential than the BRD and MMD alternatives. Under Base Condition, the westerly diversion of surface water is thought to minimize recharge by forcing water out of the basin and far to the west, where the aquifer is of insignificant thickness and recharge minimal.

4.16 General. Under provisions of the FWCA, the USFWS analyzed the net effects of each alternative operational strategy (compared with the Base Condition). They focused on key evaluation species using habitat suitability models developed through the Habitat Evaluation Procedures. The research staff of the Park developed an independent biological analysis of each plan using different models and provided it to the USFWS. These analyses were amalgamated in the FWCA Report (EIS Appendix D) and the results are summarized in Table 7. The wildlife modeling results are controversial and were not used for the selection of the recommended initial Operational Strategy; the selection was based on acceptability to the participating planning agencies. A later version of the Park's analysis is included as an appendix to the FWCA Report. The Park disagrees with the USFWS's analytical methodology, but with the exception of the snail kite, the Park's wildlife benefits numerical analysis of the alternative operations compared with the Base Condition is essentially consistent with that of the USFWS. However, the Park believes that the USFWS's HEP evaluation procedures are inappropriate for assessing the complex relationships that characterize the Everglades. In the Park's view, any similarity in numerical results between the two assessment techniques is more likely due to chance than to real agreement between the procedures. Responses to recommendations made in the FWCA Report are presented in EIS Appendix G.

4.17 Effects of Operational Alternatives on Wading Birds. The USFWS considers the wood stork (a species listed as endangered under the ESA) to be representative of other wading birds and a sensitive bio-indicator for seasonally flooded Everglades conditions. Actions that benefit the stork and wading birds include:

a) reducing the occurrence of stage reversals during spring drying, such as may be caused by regulatory releases from the WCAs;

b) expanding the extent of seasonally flooded wetlands, yielding a continuum of hydrologic conditions suitable for foraging during the entire nesting season;

c) lengthening the hydroperiod of the main stem of SRS, and providing a dry season refugium for forage fishes from which they can restock shorter hydroperiod wetlands.

The MMD Plan produced the most favorable extent and timing of flooding on a seasonal basis, according to the USFWS's wood stork analysis and the Park's wading bird colony analysis. The significant reduction in habitat suitability for the wood stork under the MRD Plan may be related to the concentration of flows into NESRS, right up to the L-31(N) on the east side. This does not allow restoration of the short hydroperiod marshes on the east side of the Slough; the resulting conversion of NESRS into a longer hydroperiod wetland may increase forage supplies while reducing their accessibility to wood storks and other wading birds. Presumably, unfavorable drying rates under the MRD Plan also caused it to perform poorly according to the Park's modeling.

4.18 Effects of Operational Alternatives on Long-hydroperiod Fish and Wildlife Communities. Snail kite nesting habitat represents the longer hydroperiod spectrum of Everglades conditions. Other wildlife components of this community include crayfish, apple snails, larger species of fish, amphibians, alligators, and turtles. Sloughs also serve as foraging areas for wading birds and mammals in the dry season or low rainfall years. The USFWS believes that protection and enhancement of kite nesting habitat in WCA 3 would also benefit this community. Lengthening of the hydroperiods in NESRS to 2-6 years would expand kite habitat also to the benefit of the rest of the community. The USFWS model for the snail kite, which was designed to identify the value of wetlands for foraging, roosting, and nesting by kites, indicated that the effects of all operational alternatives on nesting habitat for snail kites are minor. It appears likely that additional water supplies will be needed to ensure maintenance of some wetland habitat during dry years. The effects on drought refugia for kites is discussed in paragraph 4.26.

4.19 Effects of Operational Alternatives on Alligators. The USFWS considers the alligator to be a "keystone" species for the role it plays in maintaining habitat for other species. It modifies wetland habitats while creating ponds, dens, trails, and nest mounds, which in turn affects habitat suitability for other Everglades species. Alligators are relatively abundant in the Everglades because of their longevity and adaptability. Therefore, the USFWS goal is to avoid significant reduction in alligator habitat. Maintenance needs include:

a) persistent ponds or sloughs to ensure that larger forage organisms can survive drought events:

b) adequate extent of flooded habitat to produce forage;

c) relatively dependable seasonal flooding and drying progressions (especially rising water levels in late spring/early summer) to ensure nesting success.

The USFWS alligator model focuses on hydroperiod as it affects the prey base for sub-adult and adult animals. This is supplemented by the Park's analysis regarding the relationship of hydrology to population dynamics. The USFWS model showed a minimal increase in habitat suitability for all plans. Although the MRD Plan is best at moderating sudden regulatory water releases from WCA 3A that have caused alligator nest flooding in the past, the Park's population models of the alligator do not show corresponding benefit from reduced nest flooding. In fact, nest flooding was lowest under the MMD Plan. However, this is offset by increased alligator habitat value in WCA 3 under the BRD/MRD alternatives. The Park's model predicts a small overall increase in the Everglades population under all alternatives, with the best increase under the BRD alternative.

KEY INDICATORS OF ECOSYSTEM RESTORATION

4.20 Key Environmental Indicators of Ecosystem Restoration. Dr. Durbin Tabb of TBI has concluded in his report that freshwater hydric soils (peats and marls) represent the best environmental indicators of ecosystem "health".

Restoration of the hydrologic conditions that foster the continued slow accumulation of these soils in SRS will support all the major freshwater plant associations (sawgrass marshes, sloughs, needlerush-periphyton marshes, and wet prairies) and the animals that inhabit them. Dr. Tabb also believes that these hydrologic conditions would likely benefit Florida Bay by increasing recharge of the Biscayne Aquifer underlying the coastal ridge, thereby reinstating salinity-moderating groundwater flow to the estuarine areas.

4.21 Minimum Low Water Criteria for SRS Restoration. Peats must remain saturated or flooded in order to prevent loss through slumping, oxidation, or wildfire. The lower optimum limit for flood depth, therefore, should be at or slightly above the prevailing peat surfaces. Recent topographic data from the Park shows peat surfaces in this region at a mean elevation of 5.7 feet NGVD with a range between 5.0 and 6.0 feet. Sixty four percent lie at elevations between 5.0 and 5.7 feet. Since the goal is to maintain peat saturation as well as some surface water to serve as dry-season refugia for aquatic animals, the elevation of 5.7 feet NGVD is selected as the low optimum dry season level. Under optimum low level, 64 percent of the Slough would have at least some water at the surface. During moderate droughts, the extreme low water condition in Shark River Slough should not be allowed to fall below 5.0 feet, or remain at that level for more than one month if possible. When the water levels fall to 4.0 feet or below, some soil loss could be expected at all elevations above 5.0 feet and much of the peat body could ignite if passed over by wildfire.

4.22 Optimal Water Depths for SRS Restoration. A high seasonal water depth of 24 inches has been selected as the slough high optimum, with an added 12 inches tolerable at the high extreme. The 24-inch depth should be reached in at least 7 out of 10 years. This optimum high water elevation is based on the knowledge that (1) the slough plant association grows in water depths up to 36 inches; (2) the hardwood hammocks which have elevations generally at about 7 to 8 feet will seldom be flooded, and then for only brief periods; and (3) the periphyton community of the shallow marl soils in Taylor Slough headwater marshes will have 3-10 inches of standing water which is ideal for production. Evidence indicates that, in the rare case where 3 foot depths are attained, the slough plants are overtopped by strongly flowing water, thus diminishing the flow-retarding effect of this vegetation. As a result of faster flow, water levels quickly recede to about 2 feet in depth where the friction effect of vegetation once again slows seaward flow.

4.23 Comparison of Alternative Plans. Gaging station NE-1 (NESRS1 in Plate 5) in the central axis of NESRS at an elevation of 5.6 feet NGVD was selected as the key location for the optimum hydroperiod analysis. The hydrologic model predictions at NE-1 for stage-duration and stage excedance (GDM Plates E-39,40 (MMD), E-82,83 (MRD), and E-127,128 (BRD)) were compared with the criteria established for ecosystem restoration. All plans show a substantial improvement over Base Condition for hydroperiod at NE-1, but fall considerably short of optimum for seasonal high depths (Table 8). The MRD and BRD Plans were almost equal in performance. The MMD Plan was more deficient in the seasonal water depth requirement. This indicates that the volumetric component of the water delivery equation for all plans is substantially below

what is needed, or a greater proportion of the available water needs to be delivered to NESRS.

EXPERT OPINION ON POTENTIAL RESTORATION

4.24 Potential Benefits from Full Ecosystem Restoration. A quantitative analysis of benefits from full ecosystem restoration cannot be prepared at this time because a validated hydrological scenario for this condition has not yet been developed and modeled. However, it is the professional judgement of the participants in the White Paper Workshop (EIS Appendix C) that, considering the overall concept of restoration of natural hydrology rather than specific plans, the following benefits to Park resources (summarized in Table 9) would accrue.

1. Alligator population expansion into NESRS would prove beneficial to all the diverse species that are so closely linked to ecological conditions created by alligator behavior.

2. Populations of wood storks and other wading birds comparable in number to those of the early and mid-1970's (750-1000 pairs of wood storks) could be reestablished in the Park.

3. With a reversal of the degradation of the NESRS marshes, there would eventually be an increase in aquatic animal biomass correlating with renewed deposition of peats in that area.

4. A decrease in unnatural flood events would reduce mortality of tree island hardwoods. Restoration of hydropatterns in NESRS would increase the density of sawgrass in marl prairies and sawgrass in marshes, reverse the impacts of unseasonable fires, and retard invasion by exotic plants.

5. Increased wet-season runoff and late dry-season flow to the coastal bays would moderate episodes of hypersalinity, thereby making them more productive.

ENDANGERED SPECIES ANALYSIS

4.25 Coordination with the USFWS. In 1988, the USFWS advised the Corps of the potential for the considered BRD operational strategy to affect one or more of five endangered species (the snail kite, Florida panther, Cape Sable seaside sparrow, wood stork, and American crocodile), and initiated consultation on the snail kite. Subsequently the Corps determined that the considered operation might also adversely affect the wood stork, but would not be likely to adversely affect the Cape Sable seaside sparrow, the Florida panther, or the American crocodile.

4.26 USFWS Biological Opinion. In October 1988, the USFWS developed a Draft Biological Opinion stating that the BRD Operation would adversely affect snail kite Critical Habitat in WCA 3A and jeopardize the continued existence of the species. This resulted from a model-predicted increase over Base Condition in the frequency of dry-downs of the impounded water in the southeast corner of WCA 3A that provides a drought refuge for the kite. The USFWS determined that

this refuge is critical to the survival of the species because it is the last area in the Everglades to hold water during a prolonged drought. When this area dries, the kites disperse out of the Everglades and suffer high mortality. Although this drought habitat is being maintained artificially by the impounding levees and canals, it provides a substitute for other areas of long hydroperiod utilized by kites that once naturally occurred elsewhere in the Everglades, but have since been lost to development. In accordance with provisions of the Endangered Species Act when a jeopardy determination is made, the USFWS worked with the Corps to develop "prudent and reasonable alternatives" to the proposed action that would avoid jeopardy. Through iterative hydrologic modeling, the MRD Operation and the Minimum Structural Plan with the MMD Operation were developed and transmitted to the USFWS with a request for reinitiation of consultation on the kite. In April 1990, the USFWS issued a final Biological Opinion (included in the FWCA Report, EIS Appendix D) concluding that the BRD Operation would jeopardize the continued existence of the snail kite, and the other two alternatives would not represent jeopardy. It found that the MRD Operation would incidentally "take" (cause increased mortality of) kites and thus imposed terms and conditions to limit this take. None of the alternatives would jeopardize the wood stork, and the MMD Operation would actually benefit both the stork and the kite. The USFWS concurred with the Corps' determination that none of the other listed species would be adversely affected.

4.27 Reinitiation of Snail Kite Consultation. An alternative snail kite impact analysis developed by the Park professes to show that the BRD Operation would not result in jeopardy. This analysis is provided as Appendix J in the FWCA Report. Since DOI has not reconciled the conflicting analyses, the Corps accepts the USFWS's Biological Opinion. However, if any new information is developed in the future that merits reinitiation of consultation on the kite, the Corps will so request. If consultation with the USFWS is reinitiated and the BRD operation is found not to jeopardize the kite, it can be included along with other operations developed during the design/construction period as a candidate for implementation when the structures are ready for use.

MISCELLANEOUS EFFECTS

4,28 Effects of Blasting. Blasting will be necessary for excavation of the three conveyance canals between L-67A and L-67C and for the collector canal associated with the S-355s. This would have the potential to disrupt nesting activity of snail kites within a critical distance of the blast area. To prevent adverse effects on the kite, blasting will be restricted to the non-nesting season, usually May through December. This protection would also have the effect of safe-guarding nesting wading birds from disruption since their nesting season is roughly coincident with that of the kite. No blasting is expected to construct the shallow boat bypass channels.

4.29 Environmental Impacts of Bypass Channels. The channels would be constructed by use of a drag-line dredge, and the material placed on the adjacent levee. No blasting is anticipated even if rock is encountered. Approximately 7 acres of Everglades marsh would be lost as a result of the three channels. Hydrologically, the channels would allow an insignificantly small volume of water to run around the S-349 structures when the structures

are closed. This would not have any effect on the MRD Operational Plan because that plan calls for the structures to always be open. It would also not have any significant effects for potential future plans on their ability to redistribute water in WCA 3A, or to convey water into WCA 3B.

4.30 Hydrological Effects of Spreading the S-349/345 Structures. This recent revision to the recommended plan was not subjected to re-modeling because the Hydrologic Model would not be sensitive to these slight changes as a result of the size of the grid cells and way it handles discharge through structures. The greater spacing is expected to provide a somewhat more natural spread and distribution of water within WCA 3B. It would not affect the distribution of water within WCA 3A or the volume or timing of water released from WCA 3A because the flat topography along this reach of the canal would preclude any change in the original headwater-tailwater relationships across the S-345 structures.

EFFECTS ON WETLANDS

4.31 Benefits to Wetlands. When fully operational, the project will benefit the ecosystem function of approximately 100,000 acres of wetlands in NESRS, 600,000 acres of wetlands in WCA-3, and 200,000 acres of wetlands within the Shark River Slough Basin of the Park. This would result from the amelioration of the adverse conditions within the Everglades by restoration of a more natural hydrological conditions as previously discussed. In addition, the natural plant community structure in the wetlands would be maintained or restored in the following ways. The invasion of wetlands by melaleuca and other exotic plants would be curtailed by increased hydroperiod preventing germination of their seeds. The return of more natural hydrologic conditions will reduce the probability of the occurrence of destructive peat (ground) fires by reducing the time in the dry season when the moisture content of surface peats is at ignition conditions. Historically occurring wet season fires will again play a role in maintaining natural fire-resistent plant communities.

4.32 Direct Loss of Wetlands. Construction of the Full Structural Plan would result in a gross loss through dredging or filling of 230 acres of vegetated wetlands in WCA 3 and in NESRS around the residential development. The loss results from the excavation of canals and bypass channels and the construction of levees. No alternative exists that would avoid loss of wetlands, and all practicable measures have been taken to minimize the loss. Several construction features would allow for natural restoration of vegetated wetlands in areas that are now filled or are deep-water canals. Removal of L-67 ext. down to grade would allow natural reestablishment of 45 acres of wetland vegetation. Wetland vegetation would also recolonize 45 acres of the adjacent L-67 ext. canal alignment after it is back-filled with the levee material and top-dressed with peat from excavation of the S-355 collector canal. Peat obtained from excavation of the S-345 conveyance canals would be disposed of in portions of the L-67C borrow canal to bring them up to grade, thereby allowing natural colonization by wetland vegetation over a 10-acre area. Alternatively or in addition to this, the peat would be trucked to the L-67 ext. canal for top-dressing for the same purpose. Taking this into consideration, the net loss of wetlands due to construction would be 130

acres. However, this would be more than offset by the restoration of wetlands in the Everglades Basin from improved hydrology that the construction would allow. This information is summarized in Table 10 and discussed in the Clean Water Act 404(b)(1) Evaluation (EIS Appendix E). Through a similar analysis, the net loss of wetlands from the Minimum Structural Plan would be 55 acres. The above wetlands loss acreage represents a reduction from the data presented in the DEIS because the residential flood mitigation plan has been revised to delete the southern levee and the interior canal along Howard Drive. These numbers do not reflect the controversial potential loss of wetlands inside the levee resulting from the realignment issue discussed below.

4.33 Minimization of the Impacts of Wetland Losses. Construction of the conveyance and collector canals would result in the loss of 39 acres of sawgrass marsh wetlands. To offset the functional loss, consideration was given to improving the habitat value of the collector and conveyance canal banks by designing them with a shallow littoral zone of 1:10 slope down to the bottom of the peat layer (about 4 feet deep) to promote establishment of a productive emergent plant community. This habitat type is uncommon in the Everglades. The intent of its creation, therefore, would be to provide about 32 acres of important seasonal habitat for a large number of aquatic species of birds and reptiles. Recent informal coordination, however, has indicated that there would be a strong likelihood that the littoral zone would be colonized and overgrown with cattail, resulting in little if any habitat value. This would be the result of the aggressiveness with which cattail colonizes disturbed areas compared with other emergent species; nutrients would not be a factor in this instance. Littoral zones, therefore, will be abandoned unless information to the contrary is provided during public coordination.

4.34 Indirect Loss of Wetlands. The re-alignment of the residential levee (see paragraph 4.41) would result in an additional 138 acres of quality wetlands and about 62 acres of lesser quality wetlands all in private ownership being isolated within the levee system. These would be subject to development for agriculture or 40-acre residential homesteads under the current Dade County zoning. Under the former levee alignment, this acreage would have been purchased by the Corps for the levee system. The levee system is still undergoing design, but it is expected to consist of a 760-foot ROW with about 600 feet of this to be set aside as an undisturbed wetland buffer strip. The Corps' intent is to operate the flood mitigation system to control only flooding that would be in excess of base condition without the project. This is not flood protection, and as such would be unlikely to overdrain the wetlands in question. Dade County, on the other hand, has written a letter of objection (Main Report Appendix A) to the realignment based in part on their belief that the future pressure for flood control in the residential area could result in the overdrainage and loss of the wetlands. The County will be provided the opportunity to participate in the operational studies that will develop the recommended operating criteria of the residential flood mitigation system , and as a result, this issue will be addressed. The recommended operating criteria and any subsequent changes to it will require agreement among the Corps, SFWMD, the Park, the County, and DER.

4.35 Clean Water Act Requirements. A Section 404(b)(1) evaluation, required by the Clean Water Act, is included in Appendix E of the EIS. State Water Quality Certification (WQC) for discharge of dredged material into wetlands will be sought for the project prior to construction. Concurrently, this report will be processed in accordance with the procedural requirements necessary to obtain an exemption from State WQC under Section 404(r), if the Federal interest so warrants.

ANALYSIS OF WATER QUALITY ISSUES

4.36 Environmental Impacts of Nutrient Enrichment. There is concern that nutrients, particularly phosphorous, entering the Everglades system primarily from floodwater pumpage out of the EAA, as discussed in paragraph 3.05, are adversely impacting WCA 3A and the Park. Increased concentrations of nutrients, perhaps in conjunction with unnaturally high water levels, upset the ecological balance in sawgrass marshes leading to an invasion of cattail, which can out-compete established sawgrass for space in a nutrient-rich environment. This phenomenon was most evidenced by the expansion since 1979 of a 6000-acre dense cattail invasion in WCA 2A around the S-10 inflow structures. The boundaries of the cattail area had expanded by 1989 to cover an additional 14,000 acres in which cattail was "peppered" among the native sawgrass. The rapid new cattail colonization coincided with the initiation of the Lake Okeechobee Interim Action Plan (IAP). The plan involved conveying almost all the EAA flood water pumpage south to the WCAs instead of backpumping it to the Lake as a first priority. At present, much of the cattail has died-back as a result of the recent one in 100-year drought, but it is recovering and it is expected that the continued advance of the "nutrient front" under the IAP [now called the Lake Okeechobee Operating Permit (LOOP)] would result in the 14,000 acre area eventually filling in with dense cattail and further expanding. Monocultures of cattail such as this provide essentially no fish and wildlife habitat, but more importantly, cattails are indicators of ecological disturbance of the Everglades.

4.37 Water Quality Effects in WCA 3A and the Park. None of the alternative operational strategies would be expected to have a significant adverse impact on water quality in these areas over the short term. Under the BRD Operation, water is blocked from flowing south in the L-67A canal and, as a result, reaches the Park at the S-12s as sheet flow across WCA 3A. This water is characteristically of exceptionally high quality because any nutrients initially in the water entering WCA 3A from the Miami Canal would have been assimilated by marsh vegetation on the way south. There would be a slight increase in nutrient assimilation over the Base Condition in WCA 3A under these conditions resulting from the diversion of these nutrients from the Park. Under the MRD Operation and the MMD Plan, southerly flow is not blocked in the L-67A canal, and, therefore, reaches the S-12s predominantly as sheet flow during the wet season, and predominantly as canal flow during dry periods. It has only been under the latter conditions that nutrient concentrations near the S-12s have exceeded criteria in the past. This would continue to be the case under the MMD Plan and Base Condition because the operations call for minimum monthly water deliveries to the Park even under dry conditions, and this would be canal water exclusively. However, under the rainfall formula in the MRD Operation, the higher nutrient canal water at the

S-12s would not be delivered to the Park until rain events had broken the dry spell. In some circumstances, rainfall-induced flow from the adjacent marsh would dilute the nutrient concentration in the canal before water deliveries are made through the S-12s. However, supplemental water deliveries from the Lake called for during droughts would introduce additional nutrients into the Everglades system at a concentration intermediate between marsh water and EAA water. Therefore, it is concluded that, compared with the Base Condition, the MRD Operation could at times decrease the nutrient concentrations entering the Park, but could somewhat increase the nutrient loading in southern WCA 3A and the Park during supplemental water deliveries compared with the Base Condition. The BRD Operation presents a small potential for adverse water quality impacts on the wetland habitats in WCA 3A associated with a decreased potential for such impacts in the Park south of the S-12s. The MMD Plan would represent no change from the Base Condition. Over the long term, adverse water quality effects will extend south through the WCAs towards the Park as the nutrient assimilative capacity of the marsh is exceeded. The SFWMD has developed a SWIM Plan to resolve water quality issues in the EAA and WCAs. Meeting the goals of the SWIM Plan would ensure very high water quality for these areas in the future.

4.38 Water Quality Effects in WCA 3B. The absence of significant surface water connection with the surrounding Everglades has effectively isolated WCA 3B from the above described water quality problems. Existing water quality in WCA 3B is essentially unaffected by agricultural and urban runoff. To preserve this condition, the FGFWFC has expressed an objection to using WCA 3B to convey water (of potentially lower quality, in their view) from WCA 3A to the Park at NESRS until the goals of the SWIM plan are reached. The FGFWFC takes this position as the State agency with the responsibility to manage the fish and wildlife resources of the WCAs. However, elimination of conveyance through WCA 3B would severely compromise the operational potential of the recommended structural plan. The Corps believes that there would not be a quality problem with the water passing through the S-345s into WCA 3B under the BRD and MRD Operations because of the criteria under which the structures are proposed to be operated. The S-345s would not be opened unless the three-gauge average stage in WCA 3A rises to within 0.5 feet of Zone C or Zone D (depending upon season) of the regulation schedule (see Plate 16). Since the L-67A canal bank is at about 8.0 feet NGVD, the canal water would be out-of-bank under these conditions, with the WCA 3A marsh flooded. Therefore, the water passing into WCA 3B would be of equivalent quality to open marsh water. When average water level in WCA 3A drops below the above trigger stage, the structures would be closed. The only time there might be unsatisfactory water quality in the L-67A canal would be under dry conditions when the criteria call for the S-345s to be shut. Furthermore, the SFWMD's Everglades SWIM plan is expected to ultimately provide a solution to the upstream water quality problems. To ensure no problem in WCA 3B in the interim, water quality criteria will be developed and applied on a "real time" basis to govern the operation of the S-345 structures as follows. When the 3-gauge average stage calls for the structures to be opened, water quality in the L-67A Canal would be measured to be sure it met the criteria. The criteria would be selected through a public process to be compatible with the outcome of the Federal water quality lawsuit.

4.39 Water Quality Effects Associated with the Residential Area. The Florida Department of Environmental Regulation (DER) has expressed preliminary concern about water quality effects of the proposed pumpage of storm water out of the 8 1/2 sq. mi. residential area into the L-31N canal and reintroduction into the top of NESRS. Ground water tests within this area have shown that the present water quality is good. There are no known hazardous toxic waste sites within the area. It is expected that compliance with existing State and County regulations will ensure that water pumped out of the area will be of satisfactory quality. As it is conveyed north in the L-31(N) Canal, it will be augmented with about an equal volume of high quality water seeping into the canal from NESRS. This dilution represents an added safety factor for the quality of the water that would be pumped into the top of NESRS. The alternative ways of disposing of this water would be to convey it east in existing canals to Biscayne Bay, or south through C-111 to the Park's panhandle and Taylor Slough. Environmentally, these are not significantly different from the proposed plan. The former alternative would have the additional disadvantage of requiring very expensive widening of the eastern canals and their bridge crossings.

SOCIO-ECONOMIC EFFECTS

4.40 Indian Camps. There are two basic issues related to the interests of the Indian tribe: project impacts on airboat access into southern WCA 3A for commercial and religious purposes, and increases in water levels that could increase flood frequencies at two Indian camps adjacent to the Tamiami Trail. The Indians operate airboat concessions that depend upon a minimum stage of 7.4 feet NGVD at S-12B in the southern portion of WCA 3A. They also rely on airboat access for religious ceremonies held on tree islands in the same area. The project modifications that were incorporated to protect snail kite habitat in the MRD Operation would reduce the cumulative period of time with airboat access problems for the Indians compared with Base Condition by two months over the 14-year period of record. However, the BRD Operation would increase the number of months with no airboat access from 16 under Base Condition to 18 over the 14-year period of record. The corresponding figure for the MMD Operation is 11 months. Water levels in the area of the two Indian camps along the Tamiami Trail will be raised as water deliveries are made to NESRS. As a result, the camps would be flooded during parts of most years under all of the operational alternatives. The Corps has discussed two options with the residents of the Tiger Tail camp: relocation of the camp or providing fill material to raise the ground and structure elevations at the present locations. The Indians have tentatively expressed a preference for remaining in the current location and being raised. It is unlikely that the structures would withstand the stress of being moved while fill is placed and then relocated back. Consequently, the structures would be demolished and new structures constructed. The Osceola Indian camp built on the south side of the Tamiami trail lies on land that is intended for purchase by the DOI as part of the Park expansion. The Corps has been asked by the National Park Service to develop a cost comparison between flood-proofing and relocation of the camp. However, the status of the purchase and/or flood-proofing is uncertain at this time, as is the Indians' preference.

4.41 Construction of Flood Mitigation. The original alignment of the levees around the 8-1/2 sq. mi. residential area described in the DEIS was chosen to encompass the concentration of residences in the East Everglades. This alignment resulted in eight residences that fell within the levee ROW that would have to be bought-out/condemned and be removed to make way for construction. During a workshop with these residents and others in September 1990, they expressed a preference to stay in their homes instead of having to relocate. After further analysis it was decided to move the levee out to avoid these eight homes at a savings of $1,500,000 in real estate acquisition costs. There are now no dwellings within the perimeter levee and canal alignment that will be lost. **However, it should be noted that this new levee alignment may have to be shifted back, in whole or in part, depending upon the outcome of future required analyses and coordination.** The deletion of the originally proposed Howard Drive canal resulted in the removal of impacts to about 30 residences. However, there are still four to seven residences, a small mango grove, and a 40-acre mango plantation lying outside the levee alignment on the northwest side. These properties cannot be included within the levees because their isolation from the other residences makes it uneconomical to extend the levees that far west. These locations, therefore, lie within the Park expansion boundaries, and will be bought out by DOI.

4.42 Residential Area Flooding. Under Base Condition, the 8 1/2 sq. mi. residential area experiences above-ground ponding of water in the northwest corner during storms with a return frequency of about once in 5 years. This decreases with increasing land elevation to a frequency of about once in 20 years in the southeast corner. Although the flood mitigation system is not meant to flood-protect the area, there may be a slight incidental flood control benefit based on the operating assumption used in the hydrologic modeling. Quantification of this would be possible only through analysis of the effects of actual storm events in the future. However, the duration of flooding would be reduced as a result of the water being pumped-off the land, rather than draining off by gravity. Additional coordination and modeling will be required to identify the most effective operating strategy. **This system is not intended to provide flood protection. It has been designed and will be operated only to offset any increased risk of flooding over that which would occur without the project.**

4.43 Agricultural Area Flooding. P.L. 100-229, Section 104(d) provides that the Corps must construct a flood protection system for "present [December 13, 1989] agricultural uses" within the "adjacent agricultural area" shown on "Boundary Map, Everglades National Park addition, Dade County, Florida" number 160-20,013B (included in EIS Appendix A) if the Corps determines that both of the following conditions are met:

(1) Any adverse effect is attributable solely to the modifications to the C&SF Project to improve water deliveries to the Park (exclusive of land acquisition for the Park expansion) and/or the residential flood protection measures, and

(2) Such adverse effect will result in "a substantial reduction in the economic utility of such area based on its present agricultural use."

Hydrological modeling indicates that the alternative operating plans would not result in any increased flooding or rise in ground water over Base Condition. The agricultural area would, therefore, not be adversely affected, and, consequently, no provisions for flood protection are being considered. In furtherance of the provision in PL 100-229 that this determination be reviewed not later than 18 months after completion of construction, the Corps will develop a hydrologic monitoring program in the agricultural area to field-test the model predictions.

EFFECTS ON CANAL NAVIGATION

4.44 Navigational Use of the L-67 Canals. The full length of the L-67A Canal and part of the L-67C Canal are used extensively by small recreational boaters to get access to fishing areas in WCA 3A and WCA 3B. The recommended structural plan in the DEIS would have prevented boat access past the structures in the L-67A Canal, and would have blocked access to the upper half of the L-67C Canal.

4.45 Impacts of Alternatives Considered to Improve Access. Several alternative plans were evaluated for providing small boat navigational access down the entire length of the L-67A Canal, including one suggested by the fishing public (see F.A.D.E. letter of October 29, 1990). These are discussed in the Main Report Section K (Hydrology and Hydraulics), Page 79 and shown in Main Report Figures 16 through 21. Figure 22 in the Main Report indicates the benefits and deficits of each.

4.46 Impacts of the Recommended Navigation Plan. The boat bypass channel is the only practical alternative that would provide safe navigation past the structures without compromising the project objectives to hold water back in the L-67A Canal and to convey water into WCA 3B. The channel dimensions will allow safe, slow-speed passage for small (bassboat-class) vessels. Insufficient water to navigate the channels would occur only during extended droughts when water levels drop below the marsh surface, thereby providing less than 3-foot depth. Hydrologic modeling indicates that average depths in the channels would be about 5 feet (water 2-feet deep over the marsh), and that channel depths less than 3 feet would occur 5% of the time. Each channel is about 2850 feet long; at an idle speed of 5 mph, a boat would require about 6 minutes to transit around each structure. Additional fishing opportunities would result along the new channels, and under most conditions additional access to open-water areas of the marsh would be possible. As part of their required operation and maintenance of the project, the SFWMD will maintain the channels free of aquatic weed impediments to navigation. Construction of the bypass channels around the three structures would result in the conversion of about 7 acres of vegetated wetlands to open water wetlands.

4.47 Recreational fishing Enhancement. As part of the aquatic plant control program in the bypass channels, the SFWMD will be asked to also keep free of weed impediments several of the existing cutouts through the L-67A Canal western berm as selected by the FGFWFC. This would provide boaters with improved fishing and hunting access at prime locations along the canal that are now clogged by aquatic weeds.

4.48 Navigational Impacts in the L-67C Canal. The L-67C Canal would be blocked about 9 miles north of the Tamiami Trail by the containment levee of the conveyance canal from S-345C. There is no practical way this blockage can be bypassed without seriously compromising the project's ability to effectively discharge water to WCA 3B. There is also no practical way to provide boat ramps at the northern end of the L-67C Canal. The unavoidable effect of this is to exclude fishing from boats on the northern 14 miles of the L-67C Canal.

CULTURAL RESOURCES

4.49 Impacts on Cultural Resources. By letter of December 29, 1986, the Florida State Historic Preservation Officer (SHPO) determined that there is a reasonable probability that any project activities that would involve tree islands could affect properties listed or eligible for listing in the National Register of Historic Places (Main Report Appendix A). Construction will be designed to avoid tree islands. If there is an exception to this, a cultural resources survey would be conducted of any such locations prior to construction. Since levee fill material will be obtained from adjacent canal excavation, or from nearby commercial borrow pits, no additional cultural resources surveys of borrow areas are anticipated to be required. If any resources are located and determined to be listed or eligible for listing in the National Register, the Corps will assess the effects of the proposed undertaking on those resources. A plan will be formulated, in consultation with the SHPO, to mitigate any adverse effects, and the Advisory Council on Historic Preservation will be afforded an opportunity to comment. Any required mitigation will be completed prior to construction. All work will be conducted in compliance with the National Historic Preservation Act of 1966, as amended (PL 89-655); the Archeological and Historic Preservation Act, as amended (PL 93-291); and Executive Order 11593. The increases in water depths projected under the alternative plans would have no deteriorating effects on any existing cultural sites, nor would any future excavation or salvage operations be hindered in any way. Based on an initial assessment, none of the structures in the two Indian camps appear to meet the age requirements (50 years or more) nor the eligibility criteria for the National Register.

MISCELLANEOUS EFFECTS OF OPERATIONAL STRATEGIES

4.50 Lake Okeechobee Regional Water Supply. Under the Base Condition, releases of water from Lake Okeechobee to WCA 3A are made whenever the three-gage (3-3, 3-4, and 3-28) average stage in WCA 3A drops to or below 8.5 feet NGVD. This operation is unchanged under the BRD and MMD Operational Strategies. It is changed to 9.0 feet NGVD under the MRD Operation in order to maintain the snail kite drought refuge dry-out frequency below the threshold of jeopardy. Despite this transfer of supplemental water from the Lake under the MRD Operation to maintain kite habitat, it is expected that WCA 3A would still dry out during extreme droughts. These supplemental water releases were modeled subject to the same restrictions as for other water users under the "supply-side water management" plan implemented by the SFWMD a number of years ago. Based on hydrologic model output of average annual conditions compared with Base Condition (Main Report, Table 8), the MRD Operation results in 54,000 acre-feet additional water withdrawn from the

Lake. Of this, 11,000 acre-feet is supplied to the EAA and 42,000 acre-feet to WCA 3. The additional withdrawals from the Lake represent a 12% increase in water supply discharges. The corresponding figures for the BRD Operation respectively are: 13,000 acre-feet, 26,000 acre-feet, -14,000 acre-feet, and 3% increase in water supply discharges from the Lake. Water supply to South Dade County as indicated by model output of stage in the L-31N Canal is considerably improved by each of the rain-driven operations compared with the Base Condition. The reduced discharges to WCA 3 under the BRD Operation is a result of not calling for deliveries during dry periods as would occur under the MMD and Base Condition. The corresponding increase under the MRD Operation results from additional water required for the snail kite. The Corps concludes that none of these increased discharges constitute a significant adverse impact on regional water supply. Lack of significance is also shown by an analysis of simulated annual Lake volumes during drought years 1971, 1973, and 1981 (Main Report, Table 8A). During 2 out of 3 of these years, there would have been no change in Lake volume (December to December) resulting from any of the operational alternatives. In drought-year 1981, both of the BRD and MRD Operations would have resulted in 100,000 acre-feet less drop in Lake storage compared with the Base Condition. The volume of supplemental water releases from the Lake for the MRD Operation comes in large part from the volume that would otherwise have been released to tidewater for Lake regulation purposes.

4.51 Tamiami Trail (U.S. Highway 41). Under the rain-driven delivery operational strategies, water will be discharged into the L-29 borrow canal from WCA 3B. Water levels in the canal will rise and water will flow under the highway through 52 existing culverts spread across a ten mile section of the road. The goal is to raise water levels to about the levels that would have existed under natural conditions. Tamiami Trail was the first man-made feature in this area, having preceded C&SF Project features by at least 20 years. Water levels that will exist after the project is implemented are similar to, or lower than water levels that existed for more than 30 years after the highway's construction. Therefore, the project does not include any modifications to the highway. Data showing this have been provided to the Florida Department of Transportation (DOT). DOT has not yet established a position.

4.52 Hazardous Toxic Wastes. No indication of HTW was found during an inspection of the construction alignments conducted in July 1990, therefore no further action is planned. During construction, the contractor will remove the existing debris in the residential area and dispose of it in an approved manner. If any evidence of HTW is revealed at that time, work will stop and appropriate measures will be taken by the Corps to investigate and dispose of the material.

4.53 Aesthetics. The structural features of the alternative plans have been reviewed for aesthetic impacts in accordance with the National Environmental Policy Act and other applicable Federal regulations. Six of the gate structures in WCA 3A will be on or adjacent to a levee in a remote location. With the exception of fishermen or hunters and maintenance personnel, these structures will not be seen by most of the general public. The structures will stand much taller than the surrounding landscape. Three of the

structural features (S-355 A & B and S-356) will be located in separate areas along the length of levee L-29. The structures will stand approximately 20 feet above the top of the levee, which will make them taller than any of the surrounding landscape. As such, they will be visible for miles. The second pumping station (S-357) will be located on a new levee to be constructed to protect the residential area. Any effort to modify the size or shape of the gate structures or pumping station is not a practical or viable alternative. Because of constraints concerning the placement of trees and shrubs on levees, vegetation for screening of the structures may not be possible; however, all practical considerations to reduce the negative visual impacts of these structures will be pursued.

4.54 Floodplain. All the considered operational and structural alternatives for redirecting water deliveries to the Park are in accord with the goals of Executive Order (E.O.) 11988, Floodplain Management (24 May 1977), since they share the E.O. objective of restoring and preserving the natural and beneficial values of the base (100 year) floodplain within which the project area lies. The residential flood mitigation levees must be placed in the base floodplain because the residential area they surround is also in the base floodplain. The re-alignment of these levees further out into the floodplain (see paragraph 4.34) was made to prevent impacts on eight families that have residences located just outside the original alignment. This would likely increase development pressure on portions of the additional 200 acres of partially developed, privately-owned wetlands now included inside the levees. All of this land is under agricultural and residential development pressure, with several large acreage 404 permit applications denied by the Corps along SW 120th Street. This re-alignment resulted in a $1.3 million cost reduction for the flood mitigation system.

4.55 Coastal Zone. The State has concluded that the project is consistent with their authorities in the Florida Coastal Management Program (Florida DER letter of October 31, 1990).

4.56 West Dade Wellfield. Dade County is planning a new 140 million gallon per day (MGD) wellfield (60 MGD is back-up capacity for existing wellfields) to supply projected increases in municipal and industrial water demands. The proposed site is in the Bird Drive Basin just east of NESRS and immediately south of the Tamiami trail. This site is close enough that the wellfield influence (either the cone of depression or L-31(N) canal draw-down) might have the potential to adversely affect the hydrology of NESRS. This was envisioned by Congress when drafting the ENP Protection and Expansion Act [Section 104(i)], which provides that if "the Secretary [of the U.S. Department of the Interior] certifies that operation of the wellfield is ... causing significant adverse impacts on the resources of the Park, the Governor [of the State of Florida] shall require the South Florida Water Management District to take necessary actions to alleviate the adverse impact, including, but not limited to, temporary reductions in the pumpage from the wellfield." Therefore, there may be an adverse impact on operation of the wellfield, but it cannot be attributed to the GDM restoration action since it is part of the Park expansion action which is included under the GDM Base Condition. This issue will be discussed in more detail in a Corps EIS on the permit

application for the wellfield that is expected to be available in draft form in late 1990.

4.57 Future Operational Plans. The improved operational strategy that will be developed over the next five years during the design/construction phase (and any subsequent plans) will be coordinated thoroughly with the USFWS, Park, and SFWMD. It will be subject to review under the Endangered Species Act, NEPA, and other Acts if appreciably different from any of the alternative operations discussed herein. Either an Environmental Assessment with a Finding of No Significant Impact (FONSI) or a supplement to this EIS (depending on the Corps determination of the magnitude of effect on the quality of the human environment) will be issued for public review.

4.58 Cumulative Impacts on Wetland Loss. Cumulative impacts are defined as the impacts on the environment that result from the incremental impact of the considered action when added to other past, present, and reasonably foreseeable future actions. The action involved is to make structural modifications to the C&SF project to improve water management capability to deliver water to the Park. This will involve loss of 130 acres of Everglades wetlands. It is estimated that in the past 100 years almost half of the 2,500,000 acres of wetlands within the original Everglades Basin south of Lake Okeechobee have been lost through development, primarily in the EAA and along the western slope of the coastal ridge. The 864,000 acres of wetlands in the WCAs, 334,000 acres of freshwater wetlands within the original Park boundaries, and the 107,600 acres of wetlands in the East Everglades Park expansion can be assumed to be protected against loss into the foreseeable future. All together these public lands contain about 1,300,000 acres of wetlands, or almost the totality of the remaining Everglades. The balance are primarily in private ownership and are located west of the coastal ridge and abutting the public lands. It can be expected that some of these will be subject to development in the future. It also can be expected that all of the existing wetlands within the residential levee alignment will eventually be lost to agriculture or residential development.

4.59 Cumulative Impacts on Water Supply. A cumulative impact on water supply can also be expected to result from operation of the modified C&SF system. A full analysis of this effect cannot be provided until a decision is made over the next several years on the initial operation to be field-tested. The default operation (MRD) requires less water from the system than the 260,000 acre-feet mandated by the Minimum Delivery Schedule under the Base Condition. However, restoration is likely to require at least the total volume shown in Table 6 for the MRD Operation; this includes the rain-driven component plus the regulatory component. The latter, considered excess water in the system, is not mandated for delivery to the Park under the rain-driven formula. As such, it would be available to other users in the future or subject to diversion or storage. For instance, much of this excess originates from pumping flood water out of the EAA. The SWIM Plan calls for the EAA flood water to be detained in proposed Water Management Areas for reuse for irrigation in the EAA. Under these circumstances, there would be considerably less need for regulatory releases from WCA 3A to the Park, and the Park would subsequently get much less water on an annual basis under the present rain-driven delivery concept.

4.60 Unavoidable Adverse Impacts. There are no net adverse impacts in either of the structural alternatives. The BRD Operational Strategy would have a significant adverse effect on the snail kite

4.61 The Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance of Long-Term Productivity. All of the action plans will contribute to the maintenance of long-term productivity.

4.62 Irreversible and Irretrievable Commitments of Resources Which Would be Involved in the Proposed Alternative Should it be Implemented. There are no such commitments for any of the alternative plans.

IMPACTS OF NO-ACTION ALTERNATIVE

4.63 Projected Future-Without-Plan Conditions. A worst case analysis projects that over the next 50 years, the needs of other users of water in south Florida would result in water deliveries to the Park being limited to the minimum volumes mandated by PL 91-282. This would result in a gradual transition from long hydroperiod wetlands such as sawgrass to drier wetland communities such as muhly grass prairie. Fires would tend to increase in frequency and intensity. Exotic plant species such as melaleuca would continue to invade the wetlands. Wading bird populations would continue to decline. Fish populations would decrease with water levels. Deer populations may increase, as would the Cape Sable seaside sparrow if muhly grass habitat increases are not offset by a proportional increase in invasion by melaleuca. Snail kites would make less frequent use of the Park since lower water levels decrease populations of the apple snail or make them less accessible to the kite. Alligator populations would peak at a lower projected level, but would have a lower incidence of nest failures because of a reduction in the frequency of flood releases from WCA 3A. No further development would take place in the East Everglades wetlands because these lands would be acquired and incorporated into the Park.

4.64 Proposed Plan vs. Future-Without-Plan. The recommended plan establishes a procedure for developing and authorizing new water delivery strategies to the Park. These would allow for increased allocations of water as analysis from field monitoring indicated was required to retore and maintain the Park's ecosystems.

SUMMARY CONCLUSIONS

4.65 Hydrologic Restoration. The Corps believes that restoration of natural water conditions in the Park requires the restoration of historic water flow through WCA 3B. Reintroduction of surface water into WCA 3B would decrease the volume of, and in some cases, the need for unnatural regulatory water releases into the Park through the S-12 structures. It would also allow full restoration of historic water depths and hydroperiods in NESRS. These hydrologic changes are essential for the restoration of wading bird reproductive success and the complex ecological conditions that are prerequisite.

4.66 Wildlife Benefit Analyses. Wildlife models have not demonstrated appreciable benefits to fish and wildlife resources from any of the considered operational strategies. These results are controversial and have, therefore, not been used as the full basis for the selection of the recommended initial Operational Strategy. The Corps, based on the expert opinion in the White Paper, believes that restoration of natural hydrologic conditions in SRS would greatly benefit wildlife populations. The operational strategy to achieve this result will require an iterative planning and field testing program over a number of years.

4.67 Impacts on Snail Kites. The Corps accepts the USFWS's Biological Opinion (B.O.) that implementation of the BRD Operational Strategy would jeopardize the continued existence of the endangered snail kite. The USFWS is the agency within the Department of Interior (DOI) that has the responsibility for making determinations under the Endangered Species Act. Any controversy over the validity of the B.O. must be resolved within DOI. If new information on the kite from field studies or new analytical models warrant, the Corps will request reconsultation with the USFWS on the subject.

4.68 Water Quality Effects in WCA 3B. The Corps believes that a water quality (excessive nutrients) problem would not develop in WCA 3B as a result of routing water from WCA 3A through to NESRS. Water would be conveyed through WCA 3B only under high stage conditions in WCA 3A, at which time the L-67A Canal water at the discharge structures would be of equivalent quality to open marsh water. Furthermore, the SFWMD's Everglades SWIM plan is expected to ultimately provide a solution to the upstream water quality problems. To ensure no problem in WCA 3B in the interim, water quality criteria will be developed and applied on a "real time" basis to govern the operation of the S-345 structures.

5.00 COMMITMENTS AND SPECIAL CONDITIONS

5.01 Hydrological Monitoring. PL 100-229 requires that a determination of no adverse effect on agriculture be reviewed within 18 months of project completion. In furtherance of this, the Corps will develop a hydrologic monitoring program in the agricultural area to field-test the model predictions (see paragraph 4.43).

5.02 Ecological Monitoring. Additional coordination and planning with a wide range of interested parties will be conducted in the near future to develop and implement an adequate regional ecological monitoring program (see paragraph 2.23).

5.03 Boating Access along the L-67A Canal. The SFWMD will establish an aquatic weed control program to maintain clear passage through the S-349 bypass channels at all times as part of their responsibility under the Local Cooperation Agreement on O&M of the project. The SFWMD will also be asked to voluntarily include aquatic weed control in specified cut-outs in the western berm of the L-67A Canal as part of this program (see paragraph 4.47).

5.04 Refining the Recommended Operating Strategy. Over the next several years, the Corps will work with the Park, the wildlife agencies, and the SFWMD to develop a more acceptable operational strategy with which to begin an iterative field testing program of water deliveries. These will be subject to reviews under NEPA, ESA, and other Acts as appropriate (see paragraphs 2.22 and 4.57).

5.05 Water Quality Criteria for WCA 3B. Before the S-345 structures are used, water quality criteria compatible with the Federal Water Quality Lawsuit will be developed and applied on a "real time" basis to govern their operation (see paragraph 4.38).

5.06 Operating Criteria for the Residential Flood Mitigation System. Dade County will be included as an equal planning partner along with the SFWMD, the Park, and DER for development of the recommended plan of operation and any future changes to it (see paragraph 4.34).

6.00 LIST OF PREPARERS

6.01 The following people had an important role, as indicated, in the preparation of this Environmental Impact Statement.

Name	Agency	Role
Jonathan D. Moulding	Jacksonville Corps of Engineers	EIS Preparation and Coordination
Gerald L. Atmar	Jacksonville Corps of Engineers	First Level Supervision
Hanley K. Smith	Jacksonville Corps of Engineers	Second Level Supervision
Rolando Altamirano	Jacksonville Corps of Engineers	GDM Preparation and Hydrologic Analysis
Lewis Hornung	Jacksonville Corps of Engineers	Project Management
Arnold Banner	U S Fish and Wildlife Service, Vero Beach	Information for Fish and Wildlife Resource Analysis
Research Staff	Everglades National Park Research Center	Information for Fish and Wildlife Resource Analysis
Hydrology Staff	South Florida Water Management District	Hydrologic Model Development

7.00 PUBLIC INVOLVEMENT.

7.01 Public Involvement Program. The public was involved in the study by means of public meetings in Miami and numerous invitational workshop meetings in south Florida and Jacksonville. Scoping was conducted at these meetings during the Corps Feasibility Study on Shark River Slough and the current study.

7.02 Required Coordination. The USFWS has the responsibility under Section 7 of the Endangered Species Act to determine if any action considered in this report is likely to jeopardize the continued existence of any species listed under the Act.

7.03 Statement Recipients. Copies of the FEIS will be sent out for comment to all Federal, State, and local agencies that have jurisdiction by law or special expertise with respect to any environmental impact involved, or that are authorized to develop and enforce environmental standards, or any agency or organization that has requested that it receive statements on actions of the kind proposed. Copies will also be sent to everyone who commented on the DEIS and, on request, to any other interested person or organization. To help us be more constructively responsive, comments should be as specific as possible and referenced to particular paragraph numbers in the statement. They may address the adequacy of the statement and/or the merits of the alternatives discussed. Any information presented as fact rather than opinion should be documented by reference or substantiated by data. An agency that is critical of a presented predictive methodology should describe the alternative methodology that it prefers and why.

7.04 Public Views and Responses. Letters of comment on the DEIS were received from the following agencies, organizations, and individuals.

Respondent	Date
Dept. of Housing and Urban Development	16 August 1990
U.S. Dept. of Transportation	17 August 1990
Florida State Historic Preservation Officer	28 August 1990
Fishermen Against Destruction of the Everglades	4 September 1990
U.S. Dept. of Health and Human Services	6 September 1990
Dr. Peter C. Frederick	7 September 1990
U.S. Dept. of Agriculture	10 September 1990
Ms. Nancy Alvarez del Real	10 September 1990
National Marine Fisheries Service	17 September 1990
Mr. Raul A. García	23 September 1990
Drs. G. Thomas Bancroft and Wayne Hoffman	24 September 1990
Dr. Arnold Banner	7 October 1990
Florida Wildlife Federation	18 October 1990
Dr. Steven R. Beissinger	19 October 1990
Florida Game and Freshwater Fish Commission	19 October 1990
South Florida Water Management District	19 October 1990
Tropical Audubon Society, Inc.	25 October 1990
Sierra Club, Florida Chapter	26 October 1990
U.S. Environmental Protection Agency	29 October 1990

Fishermen against Destruction of the Everglades	29 October 1990
Ghioto and Associates	29 October 1990
Hydrologic Associates U.S.A., Inc.	29 October 1990
Miccosukee Tribe of Indians of Florida	29 October 1990
Mr. Harold R. Cobb	30 October 1990
Florida Dept. of Transportation	30 October 1990
Metropolitan Dade County/DERM	30 October 1990
Mr. Landon E. Thomas	30 October 1990
The Everglades Coalition	31 October 1990
Everglades Co-ordinating Council	31 October 1990
Florida Dept. of Environmental Regulation	31 October 1990
Florida Office of the Governor	31 October 1990
Peeples, Earl, and Blank	31 October 1990
Florida Dept. of Natural Resources	1 November 1990
Honorable Dante B. Fascell	2 November 1990
National Audubon Society, SE Regional Office	16 November 1990
Peeples, Earl, and Blank	13 December 1990
National Audubon Society, Research Center	4 January 1991
U.S. Department of Interior	5 February 1991

These letters along with the Corps' responses are presented in chronological order in EIS Appendix F.

Table 1. COMPARISON OF STRUCTURAL FEATURES OF ALTERNATIVES: GDM - Modified Water Deliveries to Everglades National Park

Alternative	Connection btwn WCA's 3A & 3B (S-345's)	Control of L-67A Canal Flow (S-349's)	Connection btwn WCA 3B & NESRS (S-355)	Removal of L-67 ext.	Replace S-334	Seepage Control Pumping Station	Residential Area Flood Mitigation	Need to Flood Protect Indian Camps	Construction Cost ($ x1000)
Full BRD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	80,000
Struct. MRD	Yes	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	80,000
Minimum Structures (MMD)	No	No	No	Yes	Yes**	Yes	Yes	Yes**	63,000
No-Action	No	No	No	No	No	No	No	No	

NOTES: * Structures would be built, but not operated under the initial operational iteration.

**Although there will be no direct water delivery into the L-29 canal, backflow under some conditions from NESRS through the U.S. Highway 41 culverts is expected to increase the canal flood level frequency.

"Yes" - The alternative encompasses that feature.
"No" - The alternative does not encompass that feature.

Table 2. COMPARISON OF OPERATIONAL FEATURES OF ALTERNATIVES: GDM - Modified Water Delivery To Everglades National Park

Alternative		ENP Water Delivery		WCA-3A Regulatory Releases		Drought Management	
		Rain-Driven Delivery Formula	Minimum Delivery Schedule (PL 91-282)	Stepped Release Schedule	Maximum Capacity Releases or None	WCA-3A Stage for Supplemental Water Releases from Lake Okeechobee	Water Conservation Measures
Full	BRD	Yes	No	Yes	No	8.5' NGVD	No
Struct	MRD	Yes	No	Yes	No	9.0' NGVD	Shared Adversity: 15% cutback of all water supply releases from WCA-3A when L-67A canal stage ≤ 7.5'
Minimum Structural MMD		No	Yes	No	Yes	8.5' NGVD	Shared Adversity under provisions of PL-282: Proportional cutback of all water supply releases from WCA-3A when ENP minimum delivery cannot be met
No Action		No	Yes	No	Yes	8.5' NGVD	Same as MMD

Table 3. COMPARISON OF ECOLOGICAL AND SOCIAL EFFECTS OF ALTERNATIVES: GDM - Modified Water Deliveries to Everglades National Park

		FISH AND WILDLIFE BENEFITS (ranking)*				ENDANGERED SPECIES		ECOSYSTEM RESTORATION	WETLANDS	SOCIAL EFFECTS	
		Wading Birds		Alligator							
Alternative		Wood Stork Seasonal Foraging Habitat	Colony Nesting Success	Habitat Improvement	Population Increase	Snail Kite Species Survival (ranking)	Wood Stork Population Recovery (ranking)	Maintenance of Hydric Soils (ranking)	Net Direct Loss (acres)	Miccosukee Indian Airboat Use (ranking)	Residential Flood Benefits
Full Struct.	MRD	4	3	3	4	3	4 (No Recovery)	1	130	2	yes
	BRD	3	4	1	3	4 (jeopardy)	3 (No Recovery)	1	130	4	yes
Minimum Structures (MMD)		1	1	2	2	1	1	3	55	1	yes
No-Action		2	2	4	1	2	2 (No Recovery)	4	0	3	no

*Note: Generally there are no significant differences among the alternatives. Ranking indicates relative positon (1 is best), no quantitative differences are implied.

Table 4. AVERAGE MONTHLY WATER DELIVERIES TO EVERGLADES NATIONAL PARK THROUGH THE S-12 STRUCTURES, 1971-1982*: GDM - Modified Water Deliveries to ENP.

Month	Minimum Delivery Schedule (acre-feet)	Average Total Delivery (acre-feet)	Average Regulatory Releases	
			Volume (acre-feet)	Percent of Delivery Schedule
January	22,000	23,166	1,166	5.3%
February	9,000	17,956	8,956	99.5%
March	4,000	14,232	10,232	255.8%
April	1,700	5,399	3,699	217.6%
May	1,700	6,230	4,530	266.5%
June	5,000	11,781	6,781	135.6%
July	7,400	30,647	23,247	314.1%
August	12,200	40,239	28,039	229.8%
September	39,000	65,362	26,362	67.6%
October	67,000	78,689	11,689	17.4%
November	59,000	64,613	5,613	9.5%
December	32,000	33,597	1,597	5.0%
TOTAL	260,000	391,911	131,911	50.7%

* Note: Based on actual deliveries for the period ending when the Experimental Delivery Program was initiated.

Table 5. LOCATIONS OF FAUNA AND CRITICAL HABITAT WITHIN THE EVERGLADES THAT ARE ON THE FEDERAL LIST OF THREATENED (T) AND ENDANGERED (E) SPECIES: GDM on Modified Water Deliveries to Everglades National Park.

Common Name	ENP	WCA 3	East Everglades	Status
Florida panther	X		X	E
West Indian manatee	*			E
Snail kite	*	*	X	E
Bald eagle	X	X	X	E
Cape Sable seaside sparrow	*		*	E
Brown pelican	X			E
American crocodile	*			E
Green turtle	X			E
Atlantic Ridley turtle	X			E
Loggerhead turtle	X			T
Hawksbill turtle	X			E
Leatherback turtle	X			E
Eastern indigo snake	X	X	X	T
Arctic peregrine falcon	X	X	X	E
Wood stork	X	X	X	E

* Also, Critical Habitat established within the area.

Table 6. SUMMARY OF ECOLOGICALLY SIGNIFICANT HYDROLOGIC EFFECTS OF ALTERNATIVES: GDM-Modified Water Deliveries to Everglades National Park

Parameter				Alternative: MRD	BRD	MMD	No-Action (Base)
SRS Water Deliveries (Average Seasonal total acre-feet)	Dry Season	NESRS		90,068	86,436	10,004	11,952
		Chimney		89,240	61,803	132,678	129,151
	Wet Season	NESRS		199,196	185,443	2,532	2,886
		Chimney		206,781	186,461	333,874	328,949
SRS Water Deliveries (Average % of seasonal total)	Dry Season	NESRS		62	65	11	13
		Chimney		38	36	89	87
	Wet Season	NESRS		53	51	1	1
		Chimney		48	49	99	99
SRS Average Annual Water Deliveries (acre-feet)				585,285	520,143	479,088	472,938
Hydropattern (Average % of total area within Water Depth Class)	Dry Season	NESRS	Dry	50	52	52	70
			0 - 1/2'	11	19	22	19
			1/2'- 1'	20	20	19	8
			>1	12	9	7	3
		Chimney	Dry	39	41	37	34
			0 - 1/2'	28	29	29	29
			1/2'- 1'	18	17	21	23
			>1	15	12	14	15
	Wet Season	NESRS	Dry	30	30	31	40
			0 - 1/2'	09	12	16	22
			1/2'- 1'	17	20	22	22
			>1	45	38	31	16
		Chimney	Dry	15	16	17	15
			0 - 1/2'	20	22	22	22
			1/2'- 1'	25	26	26	26
			>1	41	36	34	38
Hydroperiod (Average % of total area within monthly class)	NESRS	0 months		24	23	23	30
		1-3		4	6	8	10
		4-6		4	5	6	15
		7-9		22	26	22	19
		10-12		44	41	42	26
	Chimney	0		6	7	7	6
		1-3		5	5	5	5
		4-6		8	9	6	5
		7-9		30	32	26	25
		10-12		51	48	55	60

SOURCE: Fish and Wildlife Coordination Act Report

KEY

MRD	Modified Rain Dirven Plan
BRD	Basic Rain Driven Plan
MMD	Modified Minimum Delivery Plan
NESRS	Northeast Shark River Slough
Chimney	Northern Extension of Everglades National Park

Table 7. SUMMARY OF THE EFFECTS ON WILDLIFE OF OPERATIONAL ALTERNATIVES: GDM-Modified Water Deliveries to Everglades National Park

Attribute	Full Structural MRD	Full Structural BRD	Min. Struct. (MMD)	No Action (BASE)
Wood Stork Feeding Habitat Suitability Relating to Nesting Success (% Change from Base) (1)	-21% *	-12%	15%	0
Wading Bird Colony Average Nesting Success (14 yrs) (% Change from Base) (2)	-7%	-21%	1%	0
Alligator Habitat Suitability (% Change from Base) (1)	1.1%	1.6%	1.4%	0
Alligator Population Size (% Change from Base) (2)	8%	13%	7%	0
Snail Kite Nesting Habitat Suitability (% Change from Base) (1)	25%	29%	-1%	0
Snail Kite/Wildlife Drought Refuge (Average period between dryouts at gauge 3-28 in WCA 3A) (1)	3.5 years	2.3 years	7 years	14 years

NOTES:
1. U.S. Fish and Wildlife Service analysis
2. Everglades National Park analysis
* Statistically significant difference compared with Base Condition (USFWS Analyses only)

Key:
WCA Water Conservation Area
MRD Modified Rain Driven Operation
BRD Basic Rain Driven Operation
MMD Modified Minimum Delivery Plan

Source: FWCA Report

TABLE 8. COMPARISON OF THE HYDROPATTERNS OF ALTERNATIVE OPERATING PLANS FOR ECOSYSTEM RESTORATION: GDM-Modified Water Deliveries to Everglades National Park.

HYDROLOGIC CONDITION (percent of time)	CRITERIA*	OPERATIONAL ALTERNATIVES			
		Full Structural		Min. Struct. (MMD)	BASE
		MRD	BRD		
Stage at or Above Ground Surface	100%	92%	91%	92%	85%
Water Depth Reaches at Least 24" **	≥70%	29%	29%	7%	7%
Stage Falls Below Ground, But Above 5.0' NGVD	0	3%	4%	4%	6%
Stage Falls Between 5.0' and 4.0' NGVD	0	4%	5%	4%	7%
Stage Falls Below 4.0' NGVD	0	1%	0%	0%	2%

* Developed by TBI at Gauge NE-1 in NESRS.

** Derived from stage hydrographs; all others derived from stage excedance curves.

1a

Table 9. COMPARISON OF HISTORIC, EXISTING AND POTENTIAL FUTURE ECOLOGICAL CONDITIONS IN THE EVERGLADES BASED ON EXPERT OPINION DEVELOPED AT THE 1987 WHITE PAPER WORKSHOP:

GDM - Modified Water Deliveries to Everglades National Park

	Woodstorks/Wading Birds	Fish	Alligators	Nutrients/ Vegetation	Water Quality	Periphyton	Vegetative Communities	Fires	Exotic Plants
NATURAL/HISTORIC CONDITIONS	Colonies in coastal mangrove marsh November-December nest initiation High rate of nesting success (6 of 7 yrs) 2000-4000 nesting pairs of wood storks	High densities, biomass and species diversity No exotic species	As many as 1,000,000 alligators Minimal nest flooding and egg mortality Population concentrated in central slough including NESRS	Low nutrient levels evidenced by predominate macrophyte and periphyton communities - sawgrass dominant Macrophyte-periphyton communties charcterized by high species richness	Nutrient deficient. Inorganic phosphate limiting nutrient Dominant inorganic ions are calcium & bicarbonate	Periphyton mats covered wider areas of lower Everglades	Natural diversity of vegetative communities associated to great extent with natural hydrologic conditions	Associated with lightning primarily during wet season	Were not a problem
EXISTING CONDITIONS	Colonies in central WCA3 Feb-March nest starts Low rate of nesting success (3-10 yrs) 375 nesting pairs of wood storks	Low, densities biomass & diversities 7 exotic species especially in NESRS	Population reduced to 10-20% of original by 1960's but population is now recovering Increased nest flooding and egg mortality Population now concentrated in western SRS	Shifts from sawgrass to cattail dominance Shift of periphyton communities toward lower abundance of diatoms & desmids results from higher nutrients	Increasing concentration of sodium, chloride, magnesium, color & iron Increased conductance Increased concentration of nutrients, primarily phosphorous and nitrogen High pesticide & heavy metals in canal bottoms	Reduced areal periphyton coverage Changes in periphyton communtities to poorer quality forage for fish Changed periphyton communities that have resulted in lower DO	Sawgrass density & abundance altered due to both prolonged innundation and drought Reduced sawgrass density in southern WCA 3A & NESRS Water mgmt exaggerated droughts have caused increases in willow in park and northern Taylor Slough Tree islands southerned WCA 3A replaced due to flooding	Increased dry season fire frequency Changes in vegetative communtities- loss of tree islands Loss of organic soils Changing topography Releases of nutrients Spreading exotic species - notably Melaleuca and Schinus	Casuarina and Melaleuca have spread westward across East Everglades

Table 9 (Cont.). COMPARISON OF HISTORIC, EXISTING AND POTENTIAL FUTURE ECOLOGICAL CONDITIONS IN THE EVERGLADES BASED ON EXPERT OPINION DEVELOPED AT THE 1987 WHITE PAPER WORKSHOP

GDM - Modified Water Deliveries to Everglades National Park

Woodstorks/Wading Birds	Fish	Alligators	Nutrients/ Vegetation	Water Quality	Periphyton	Vegetative Communities	Fires	Exotic Plants
FUTURE WITHOUT PROJECT CONDITIONS								
Further losses in southern breeding population	Continuation of current conditions	Potential for increased nest flooding would cause serious reductions in breeding stocks Restricted range to western SRS outside traditional range	Continued vegetative community shifts and reduced DO levels	Continued water quality problems. Major ion, color &iron will increase to equilibrium Further increases in nitrogen and phosphorous Pesticides & heavy metals will migrate toward Park	Continued undesirable shifts in periphyton communities thus reducing the overall aquatic productivity of the system	Continued shifts in vegetative communities	Increased frequency of dry season fires and problems currently being experienced Additional prescribed burning will be required to control the spread of unfavorable conditions	Melaleuca will become an increasing problem - entering Park from East Everglades
FUTURE CONDITIONS WITH MINIMUM STRUCTURAL PLAN								
Minimal increases during optimal water years only	Intermediate increases south of the Tamiami Trail only	Recovery in SRS No recovery in WCA 3B	Reduction in community shifts in NESRS No change in WCA 3B	General improvement in water quality at Park inflow points Decreased nutrients in lower L-67A canal Decreased contaminated sediment transport	Reduction in shifts in NESRS No recovery in WCA 3B	Reduction in shifts in NESRS No change in WCA 3B	Reduced frequency in NESRS No change in WCA 3B	Natural marsh will be invigorated except for eastern edge Melaleuca will still be a problem in WCA 3B

*These conditions were derived by the Corps through interpolation from the White Paper.

Table 9 (Cont.). COMPARISON OF HISTORIC, EXISTING AND POTENTIAL FUTURE ECOLOGICAL CONDITIONS IN THE EVERGLADES BASED ON EXPERT OPINION DEVELOPED AT THE 1987 WHITE PAPER WORKSHOP

GDM - Modified Water Deliveries to Everglades National Park

FUTURE CONDITIONS WITH FULL STRUCTURAL PLAN*

Woodstorks/Wading Birds	Fish	Alligators	Nutrients/ Vegetation	Water Quality	Periphyton	Vegetative Communities	Fires	Exotic Plants
Increase in wading bird populations to 1970's levels (750-1,000 pairs of wood storks)	Fish population will be enhanced substantially	Enhanced recovery of population Restablish traditional range	Routing of additional flows through WCA 3B should delay nutrient impacts until regional plan can be developed & implemented*	General improvement in water quality at Park inflow points Decreased nutrients in lower L-67A canal Decreased contaminated sediment transport	Periphyton communities, will be restored	Natural, preproject vegetative communities will become reestablished particularly in NESRS, immediately west of L-67 Ext, Southern WCA 3A, and WCA 3B	Return of more natural hydrology will reduce the frequency of dry season fires and the associated damage	Natural marsh communities should be invigorated Probability of exotic plant invasion will be reduced

Source: White Paper (EIS Appendix C)

*This opinion was developed before the SWIM Plan was conceived.

TABLE 10. ESTIMATE OF WETLANDS DREDGE AND FILL FOR FULL STRUCTURAL PLAN: GDM - Modified Water Deliveries to Everglades National Park

	Wetlands Loss/(Gain)			
	Acres		Cu. Yds.	
Plan Feature	Dredge	Fill	Dredge	Fill
Residential Levees	-	96	-	519,000
Residential Canals	36	-	496,000	
S-345 Conveyance Canals	35	-	222,000	-
S-345 Containment Levees		35	-	540,000
S-345 Peat Disposal Sites*	-	(10)	-	190,000
S-349 Interceptor Levees	-	4	-	40,000
S-349 Boat Bypass Channels	7	-	30,000	-
S-355 Collection Canal	4	-	17,000	-
S-334 Tieback Levees	-	4	_	40,000
S-356 Conveyance Canal	5	-	74,000	-
L-29 Relocation	-	3	-	40,000
L-67 ext. Removal**	-	(45)	-	610,000
L-67 ext. Canal Fill**	-	(45)	-	-
Hwy. 41 Roadbed Raising	-	1	-	35,000
Net Amount	87	43	809,000	2,014,000
Totals	130 acres		2,823,00	

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* Dredged peat will be placed in L-67C borrow canal up to existing marsh topography. Alternatively, this material may be used to top-off the L-67 ext. canal fill.

** Levee fill will be removed down to existing marsh topography and placed in the adjacent borrow canal, filling it to within an estimated 2 to 3 feet of existing topography.

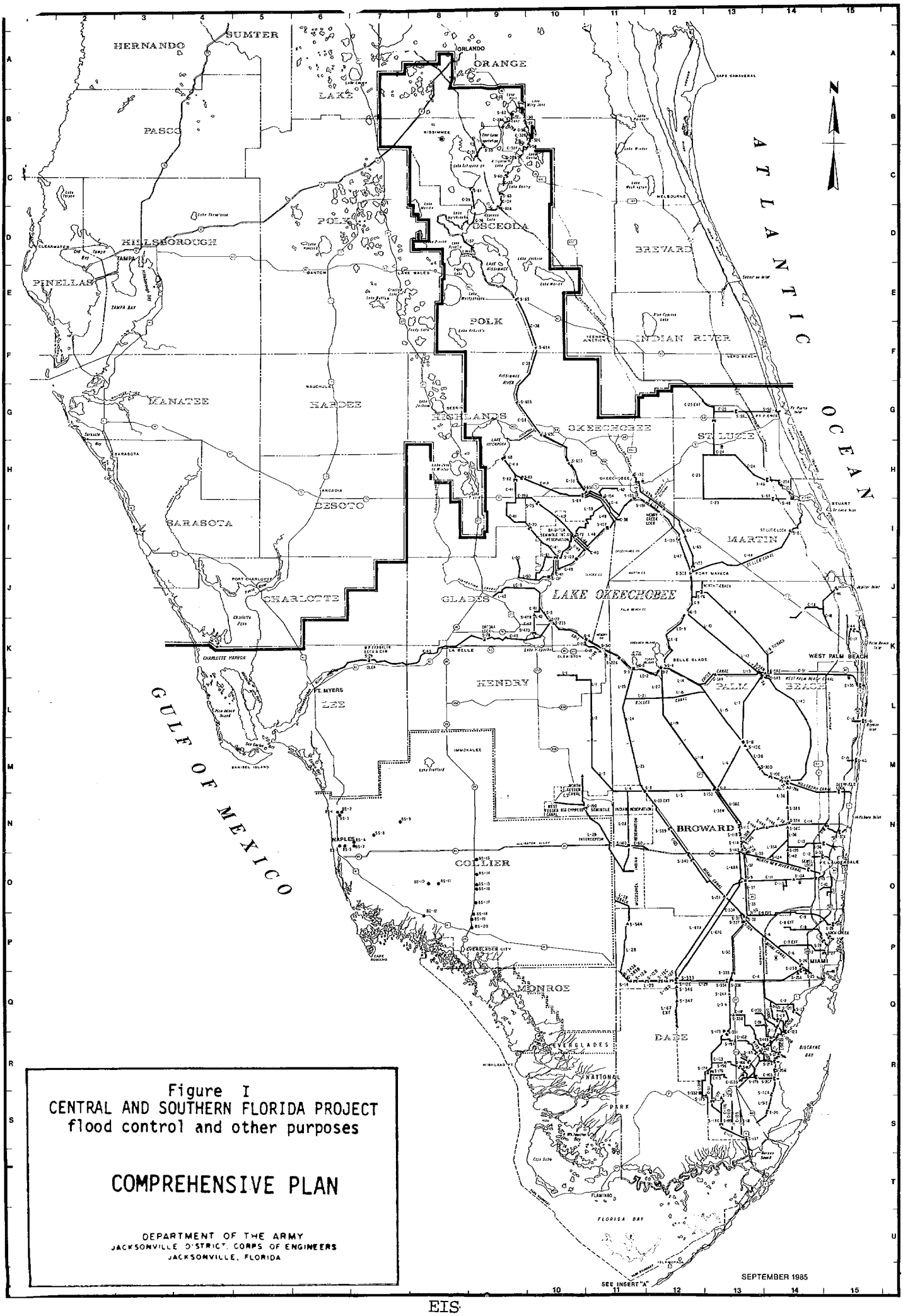

Figure I
CENTRAL AND SOUTHERN FLORIDA PROJECT
flood control and other purposes

COMPREHENSIVE PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

SEPTEMBER 1985

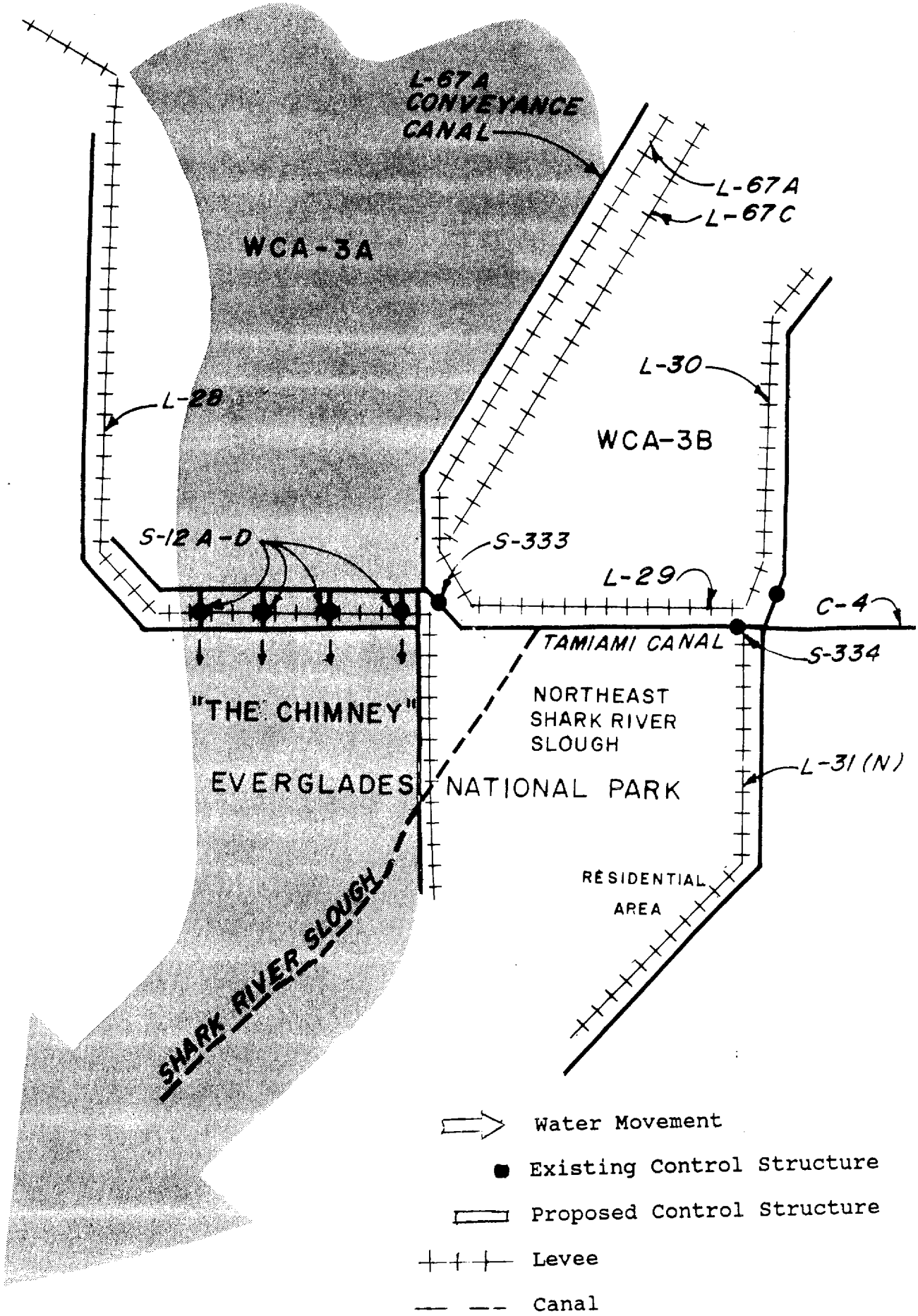

Figure 2. BASE CONDITION: SCHEMATIC DIAGRAM OF WATER DELIVERY TO THE PARK UNDER THE C&SF FLOOD CONTROL PROJECT: GDM - Modified Water Deliveries to Everglades National Park (Note: Some existing features are omitted for clarity. Park is shown with its newly expanded boundaries). EIS

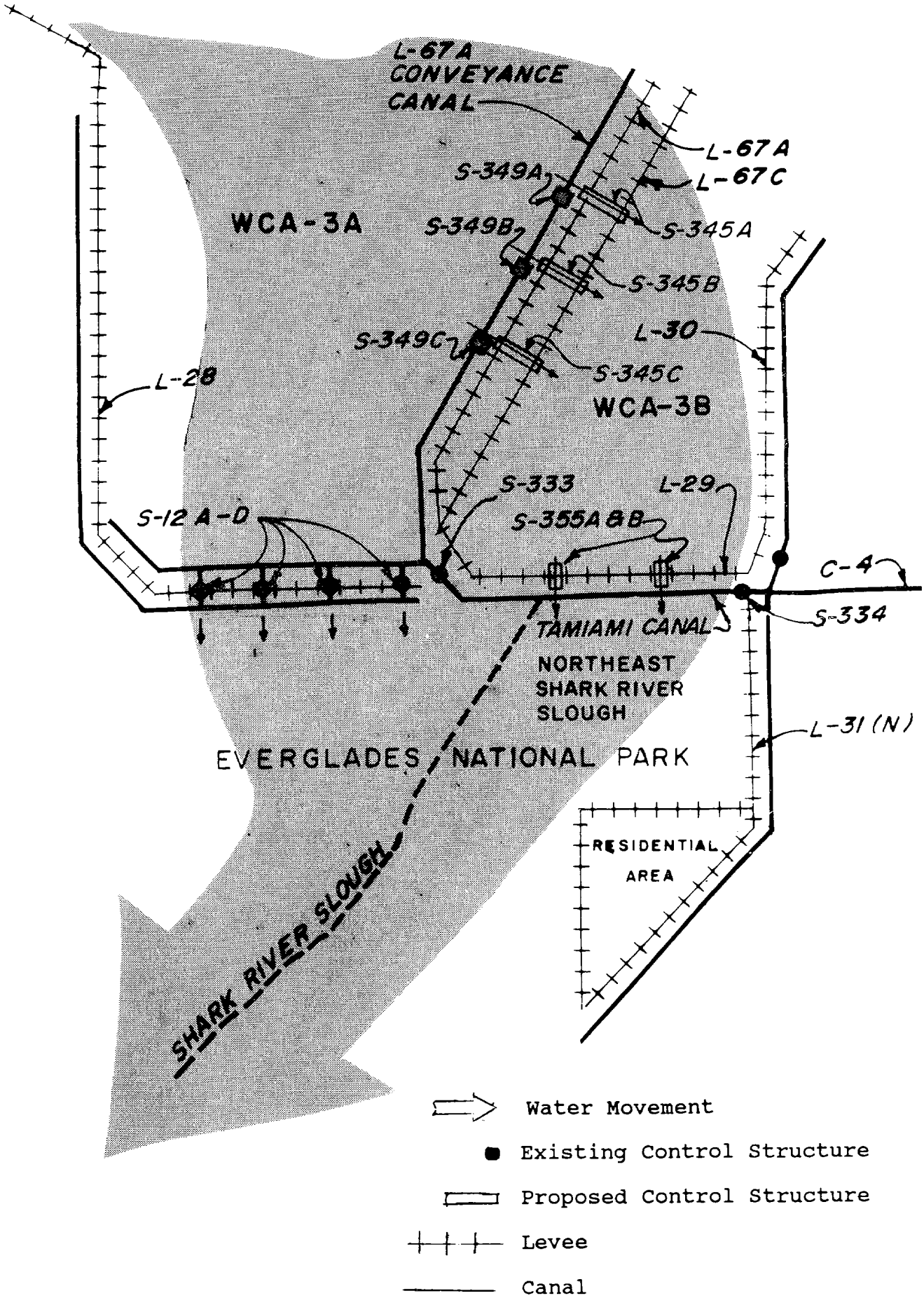

Figure 3. FULL STRUCTURAL PLAN: SCHEMATIC DIAGRAM OF WATER DELIVERY TO THE PARK: GDM - Modified Water Delivery to the Park (Note: Some existing features are omitted for clarity. Park is shown with its newly expanded boundaries.

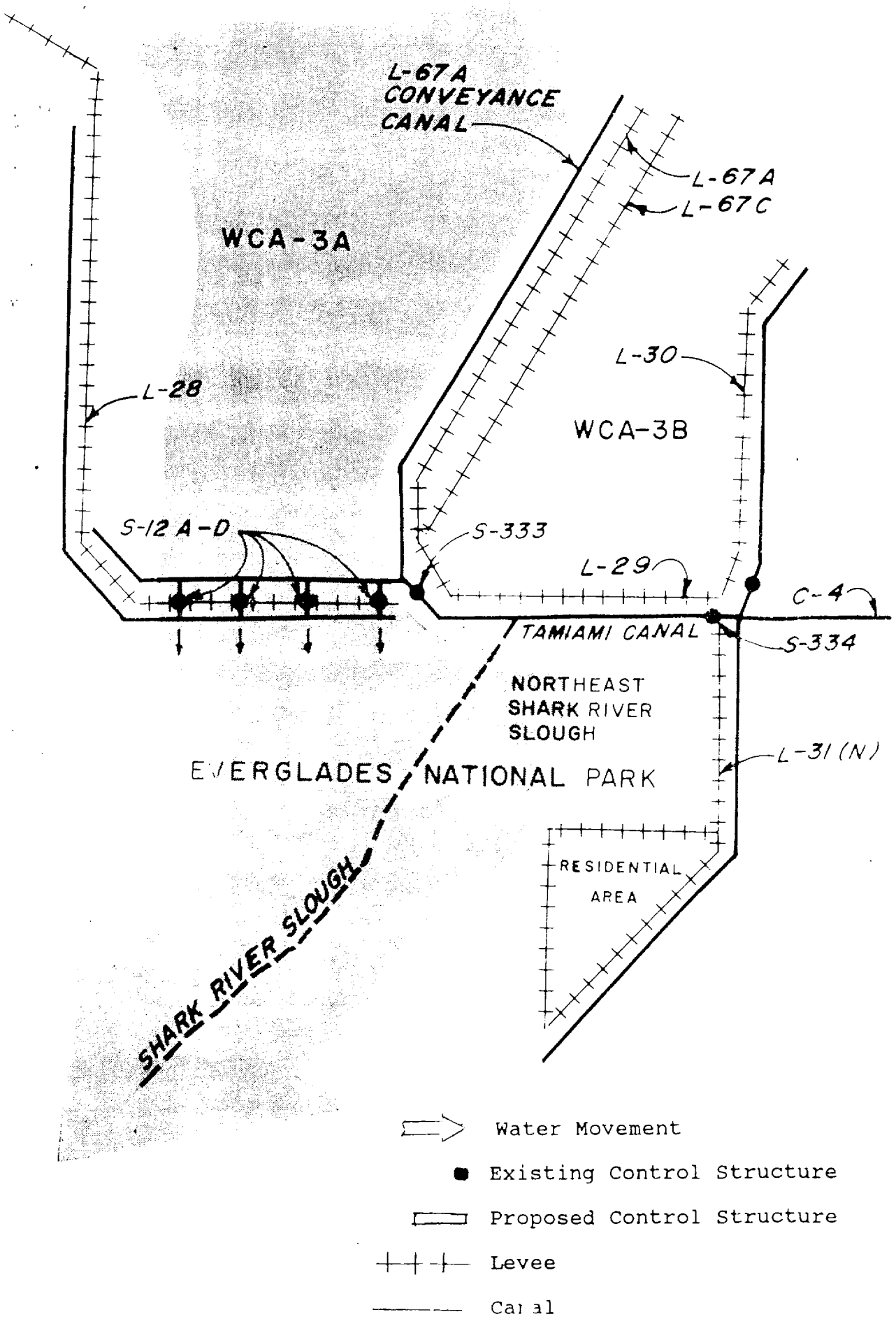

Figure 4. MINIMUM STRUCTURAL PLAN: SCHEMATIC DIAGRAM OF WATER DELIVERY TO THE PARK: GDM - Modified Water Deliveries to Everglades National Park (Note: Some existing features are omitted for clarity. Park is shown with its newly expanded boundaries

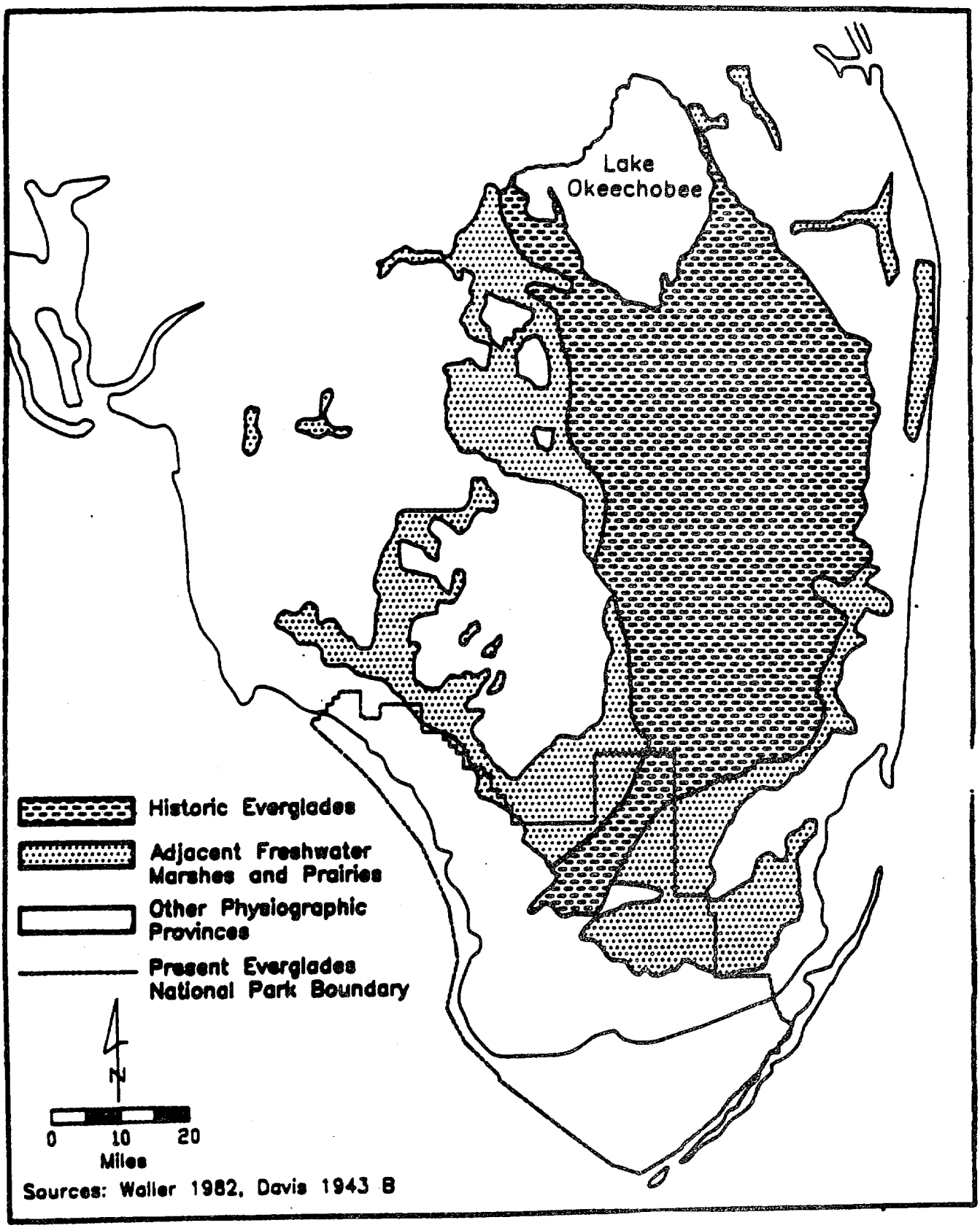

Figure 5. BOUNDARIES OF THE HISTORICAL EVERGLADES BASIN. GDM - Modified Water Deliveries to Everglades National Park

EIS APPENDIX A

EVERGLADES NATIONAL PARK PROTECTION AND EXPANSION ACT OF 1989

(PUBLIC LAW 101-229, DECEMBER 13, 1989)

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Central and Southern Florida Project
Part 1, Supplement 54

Public Law 101-229
101st Congress

An Act

Dec. 13, 1989
[H.R. 1727]

To modify the boundaries of the Everglades National Park and to provide for the protection of lands, waters, and natural resources within the park, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Everglades National Park Protection and Expansion Act of 1989.
Florida.
16 USC 410r-5 note.

SECTION 1. SHORT TITLE.

This Act may be cited as the "Everglades National Park Protection and Expansion Act of 1989".

TITLE I—EVERGLADES NATIONAL PARK EXPANSION

16 USC 410r-5.

SEC. 101. FINDINGS, PURPOSES AND DEFINITION OF TERMS.

(a) FINDINGS.—The Congress makes the following findings:

(1) The Everglades National Park is a nationally and internationally significant resource and the park has been adversely affected and continues to be adversely affected by external factors which have altered the ecosystem including the natural hydrologic conditions within the park.

(2) The existing boundary of Everglades National Park excludes the contiguous lands and waters of the Northeast Shark River Slough that are vital to long-term protection of the park and restoration of natural hydrologic conditions within the park.

(3) Wildlife resources and their associated habitats have been adversely impacted by the alteration of natural hydrologic conditions within the park, which has contributed to an overall decline in fishery resources and a 90 percent population loss of wading birds.

(4) Incorporation of the Northeast Shark River Slough and the East Everglades within the park will limit further losses suffered by the park due to habitat destruction outside the present park boundaries and will preserve valuable ecological resources for use and enjoyment by future generations.

(5) The State of Florida and certain of its political subdivisions or agencies have indicated a willingness to transfer approximately 35,000 acres of lands under their jurisdiction to the park in order to protect lands and water within the park, and may so transfer additional lands in the future.

(6) The State of Florida has proposed a joint Federal-State effort to protect Everglades National Park through the acquisition of additional lands.

(b) PURPOSE.—The purposes of this Act are to—

(1) increase the level of protection of the outstanding natural values of Everglades National Park and to enhance and restore

the ecological values, natural hydrologic conditions, and public enjoyment of such area by adding the area commonly known as the Northeast Shark River Slough and the East Everglades to Everglades National Park; and

(2) assure that the park is managed in order to maintain the natural abundance, diversity, and ecological integrity of native plants and animals, as well as the behavior of native animals, as a part of their ecosystem.

(c) DEFINITIONS.—As used in this Act:

(1) The term "Secretary" means the Secretary of the Interior.

(2) The term "addition" means the approximately 107,600 acre area of the East Everglades area authorized to be added to Everglades National Park by this Act.

(3) The term "park" means the area encompassing the existing boundary of Everglades National Park and the addition area described in paragraph (2).

(4) The term "project" means the Central and Southern Florida Project.

SEC. 102. BOUNDARY MODIFICATION.

16 USC 410r-6.

(a) AREA INCLUDED.—The park boundary is hereby modified to include approximately 107,600 acres as generally depicted on the map entitled "Boundary Map, Everglades National Park Addition, Dade County, Florida", numbered 160-20,013B and dated September 1989. The map shall be on file and available for public inspection in the offices of the National Park Service, Department of the Interior.

Public information.

(b) BOUNDARY ADJUSTMENT.—The Secretary may from time to time make minor revisions in the boundaries of the park in accordance with section 7(c) of the Land and Water Conservation Fund Act of 1965 (16 U.S.C. 4601-4 and following). In exercising the boundary adjustment authority the Secretary shall ensure all actions will enhance resource preservation and shall not result in a net loss of acreage from the park.

(c) ACQUISITION.—(1) Within the boundaries of the addition described in subsection (a), the Secretary may acquire lands and interests in land by donation, purchase with donated or appropriated funds, or exchange. For purposes of acquiring property by exchange, the Secretary may, notwithstanding any other provision of law, exchange the approximately one acre of Federal land known as "Gilberts' Marina" for non-Federal land of equal value located within the boundaries of the addition. Any lands or interests in land which are owned by the State of Florida or any political subdivision thereof, may be acquired only by donation.

(2) It is the express intent of Congress that acquisition within the boundaries of the addition shall be completed not later than 5 years after the date of enactment of this section. The authority provided by this section shall remain in effect until all acquisition is completed.

Termination date.

(d) ACQUISITION OF TRACTS PARTIALLY OUTSIDE BOUNDARIES.—When any tract of land is only partly within boundaries referred to in subsection (a), the Secretary may acquire all or any portion of the land outside of such boundaries in order to minimize the payment of severance costs. Land so acquired outside of the boundaries may be exchanged by the Secretary for non-Federal lands within the boundaries, and any land so acquired and not utilized for exchange shall be reported to the General Services Administration for disposal

under the Federal Property and Administrative Services Act of 1949 (63 Stat. 377).

(e) OFFERS TO SELL.—In exercising the authority to acquire property under this Act, the Secretary shall give prompt and careful consideration to any offer made by any person owning property within the boundaries of the addition to sell such property, if such owner notifies the Secretary that the continued ownership of such property is causing, or would result in undue hardship.

(f) AUTHORIZATION OF APPROPRIATIONS.—(1) Subject to the provisions of paragraph (2), there are hereby authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

(2) With respect to land acquisition within the addition, not more than 80 percent of the cost of such acquisition may be provided by the Federal Government. Not less than 20 percent of such cost shall be provided by the State of Florida.

(g) ASSISTANCE.—Upon the request of the Governor of the State of Florida, the Secretary is authorized to provide technical assistance and personnel to assist in the acquisition of lands and waters within the Kissimmee River/Lake Okeechobee/Everglades Hydrologic Basin, including the Big Cypress Swamp, through the provision of Federal land acquisition personnel, practices, and procedures. The State of Florida shall reimburse the Secretary for such assistance in such amounts and at such time as agreed upon by the Secretary and the State. Notwithstanding any other provision of law, reimbursement received by the Secretary for such assistance shall be retained by the Secretary and shall be available without further appropriation for purposes of carrying out any authorized activity of the Secretary within the boundaries of the park.

16 USC 410r-7.

SEC. 103. ADMINISTRATION.

(a) IN GENERAL.—The Secretary shall administer the areas within the addition in accordance with this Act and other provisions of law applicable to the Everglades National Park, and with the provisions of law generally applicable to units of the national park system, including the Act entitled "An Act to establish a National Park Service, and for other purposes", approved August 25, 1916 (39 Stat. 535; 16 U.S.C. 1-4). In order to further preserve and protect Everglades National Park, the Secretary shall utilize such other statutory authority as may be available to him for the preservation of wildlife and natural resources as he deems necessary to carry out the purposes of this Act.

(b) PROTECTION OF ECOSYSTEM.—The Secretary shall manage the park in order to maintain the natural abundance, diversity, and ecological integrity of native plants and animals, as well as the behavior of native animals, as a part of their ecosystem.

Boating.

(c) PROTECTION OF FLORA AND FAUNA.—The park shall be closed to the operation of airboats—

(1) except as provided in subsection (d); and

(2) except that within a limited capacity and on designated routes within the addition, owners of record of registered airboats in use within the addition as of January 1, 1989, shall be issued nontransferable, nonrenewable permits, for their individual lifetimes, to operate personnally-owned airboats for noncommercial use in accordance with rules prescribed by the Secretary to determine ownership and registration, establish

uses, permit conditions, and penalties, and to protect the biological resources of the area.

(d) CONCESSION CONTRACTS.—The Secretary is authorized to negotiate and enter into concession contracts with the owners of commercial airboat and tour facilities in existence on or before January 1, 1989, located within the addition for the provision of such services at their current locations under such rules and conditions as he may deem necessary for the accommodation of visitors and protection of biological resources of the area.

(e) VISITOR CENTER.—The Secretary is authorized and directed to expedite the construction of the visitor center facility at Everglades City, Florida, as described in the Development Concept Plan, Gulf Coast, dated February 1989, and upon construction shall designate the visitor center facility as "The Marjory Stoneman Douglas Center" in commemoration of the vision and leadership shown by Mrs. Douglas in the protection of the Everglades and Everglades National Park.

Marjory Stoneman Douglas.

SEC. 104. MODIFICATION OF CERTAIN WATER PROJECTS.

16 USC 410r-8.

(a) IMPROVED WATER DELIVERIES.—(1) Upon completion of a final report by the Chief of the Army Corps of Engineers, the Secretary of the Army, in consultation with the Secretary, is authorized and directed to construct modifications to the Central and Southern Florida Project to improve water deliveries into the park and shall, to the extent practicable, take steps to restore the natural hydrological conditions within the park.

(2) Such modifications shall be based upon the findings of the Secretary's experimental program authorized in section 1302 of the 1984 Supplemental Appropriations Act (97 Stat. 1292) and generally as set forth in a General Design Memorandum to be prepared by the Jacksonville District entitled "Modified Water Deliveries to Everglades National Park". The Draft of such Memorandum and the Final Memorandum, as prepared by the Jacksonville District, shall be submitted as promptly as practicable to the Committee on Energy and Natural Resources and the Committee on Environment and Public Works of the United States Senate and the Committee on Interior and Insular Affairs and the Committee on Public Works and Transportation of the United States House of Representatives.

(3) Construction of project modifications authorized in this subsection and flood protection systems authorized in subsections (c) and (d) are justified by the environmental benefits to be derived by the Everglades ecosystem in general and by the park in particular and shall not require further economic justification.

(4) Nothing in this section shall be construed to limit the operation of project facilities to achieve their design objectives, as set forth in the Congressional authorization and any modifications thereof.

(b) DETERMINATION OF ADVERSE EFFECT.—(1) Upon completion of the Final Memorandum referred to in subsection (a), the Secretary of the Army, in consultation with the South Florida Water Management District, shall make a determination as to whether the residential area within the East Everglades known as the "Eight and One-Half Square Mile Area" or adjacent agricultural areas, all as generally depicted on the map referred to in subsection 102(a), will be adversely affected by project modifications authorized in subsection (a).

Agriculture and agricultural commodities.

(2) In determining whether adjacent agricultural areas will be adversely affected, the Secretary of the Army shall consider the impact of any flood protection system proposed to be implemented pursuant to subsection (c) on such agricultural areas.

(c) FLOOD PROTECTION; EIGHT AND ONE-HALF SQUARE MILE AREA.—If the Secretary of the Army makes a determination pursuant to subsection (b) that the "Eight and One-Half Square Mile Area" will be adversely affected, the Secretary of the Army is authorized and directed to construct a flood protection system for that portion of presently developed land within such area.

(d) FLOOD PROTECTION; ADJACENT AGRICULTURAL AREA.—(1) If the Secretary of the Army determines pursuant to subsection (b) that an adjacent agricultural area will be adversely affected, the Secretary of the Army is authorized and directed to construct a flood protection system for such area. Such determination shall be based on a finding by the Secretary of the Army that:

(A) the adverse effect will be attributable solely to a project modification authorized in subsection (a) or to a flood protection system implemented pursuant to subsection (c), or both; and

(B) such modification or flood protection system will result in a substantial reduction in the economic utility of such area based on its present agricultural use.

(2) No project modification authorized in subsection (a) which the Secretary of the Army determines will cause an adverse effect pursuant to subsection (b) shall be made operational until the Secretary of the Army has implemented measures to prevent such adverse effect on the adjacent agricultural area: *Provided,* That the Secretary of the Army or the South Florida Water Management District may operate the modification to the extent that the Secretary of the Army determines that such operation will not adversely affect the adjacent agricultural area: *Provided further,* That any preventive measure shall be implemented in a manner that presents the least prospect of harm to the natural resources of the park.

(3) Any flood protection system implemented by the Secretary of the Army pursuant to this subsection shall be required only to provide for flood protection for present agricultural uses within such adjacent agricultural area.

(4) The acquisition of land authorized in section 102 shall not be considered a project modification.

Agriculture and agricultural commodities.

(e) PERIODIC REVIEW.—(1) Not later than 18 months after the completion of the project modifications authorized in subsection (a), and periodically thereafter, the Secretary of the Army shall review the determination of adverse effect for adjacent agricultural areas.

(2) In conducting such review, the Secretary of the Army shall consult with all affected parties, including, but not limited to, the Secretary, the South Florida Water Management District and agricultural users within adjacent agricultural areas.

(3) If, on the basis of such review, the Secretary of the Army determines that an adjacent agricultural area has been, or will be adversely affected, the Secretary of the Army is authorized and directed, in accordance with the provisions of subsection (d), to construct a flood protection system for such area: *Provided,* That the provisions of subsection (d)(2) shall be applicable only to the extent that the Secretary, in consultation with the Secretary of the Army, determines that the park will not be adversely affected.

(4) The provisions of this subsection shall only be applicable if the Secretary of the Army has previously made a determination that such adjacent agricultural area will not be adversely affected.

(f) CURRENT CANAL OPERATING LEVELS.—Nothing in this section shall be construed to require or prohibit the Secretary of the Army or the South Florida Water Management District from maintaining the water level within any project canal below the maximum authorized operating level as of the date of enactment of this Act.

(g) NO LIMITATION ON OTHER CLAIMS.—If the Secretary of the Army makes a determination of no adverse effect pursuant to subsection (b), such determination shall not be considered as a limitation or prohibition against any available legal remedy which may otherwise be available.

(h) COORDINATION.—The Secretary and the Secretary of the Army shall coordinate the construction program authorized under this section and the land acquisition program authorized in section 102 in such a manner as will permit both to proceed concurrently and as will avoid unreasonable interference with property interests prior to the acquisition of such interests by the Secretary under section 102.

(i) WEST DADE WELLFIELD.—No Federal license, permit, approval, right-of-way or assistance shall be granted or issued with respect to the West Dade Wellfield (to be located in the Bird Drive Drainage Basin, as identified in the Comprehensive Development Master Plan for Dade County, Florida) until the Secretary, the Governor of the State of Florida, the South Florida Water Management District and Dade County, Florida enter into an agreement providing that the South Florida Water Management District's water use permit for the wellfield, if granted, must include the following limiting conditions: (1) the wellfield's peak pumpage rate shall not exceed 140,000,000 gallons per day; (2) the permit shall include reasonable, enforceable measures to limit demand on the wellfield in times of water shortage; and (3) if, during times of water shortage, the District fails to limit demand on the wellfield pursuant to (2), or if the District limits demand on the wellfield pursuant to (2), but the Secretary certifies that operation of the wellfield is still causing significant adverse impacts on the resources of the Park, the Governor shall require the South Florida Water Management District to take necessary actions to alleviate the adverse impact, including, but not limited to, temporary reductions in the pumpage from the wellfield.

(j) PROTECTION OF NATURAL VALUES.—The Secretary of the Army is directed in analysis, design and engineering associated with the development of a general design memorandum for works and operations in the "C-111 basin" area of the East Everglades, to take all measures which are feasible and consistent with the purposes of the project to protect natural values associated with Everglades National Park. Upon completion of a general design memorandum for the area, the Secretary shall prepare and transmit a report to the Committee on Energy and Natural Resources and the Committee on Environment and Public Works of the United States Senate and the Committee on Interior and Insular Affairs and the Committee on Public Works and Transportation of the United States House of Representatives on the status of the natural resources of the C-111 basin and functionally related lands.

Reports.

A-7

TITLE II—FORT JEFFERSON NATIONAL MONUMENT REDESIGNATION STUDY

SEC. 201. FORT JEFFERSON NATIONAL MONUMENT REDESIGNATION STUDY.

The Secretary shall prepare and transmit to the Committee on Energy and Natural Resources of the Senate and the Committee on Interior and Insular Affairs of the House of Representatives, not later than 2 years after the date of enactment of this Act, a feasibility and suitability study of expanding and redesignating Fort Jefferson National Monument in the Dry Tortugas as Fort Jefferson National Park. The study shall include cost estimates for any necessary acquisition, development, operation, and maintenance, as well as alternatives, including a joint Federal and State management scheme, to further protect the waters, reef tracts, fisheries, and shallow banks in and around the Florida Keys and Fort Jefferson National Monument.

Approved December 13, 1989.

LEGISLATIVE HISTORY—H.R. 1727 (S. 724):

HOUSE REPORTS: No. 101-182, Pt. 1 (Comm. on Interior and Insular Affairs) and Pt. 2 (Comm. on Public Works and Transportation).

CONGRESSIONAL RECORD, Vol. 135 (1989):
Nov. 7, considered and passed House.
Nov. 21, considered and passed Senate, amended, in lieu of S. 724. House concurred in Seante amendment.

WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 25 (1989):
Dec. 13, Presidential statement.

A-8

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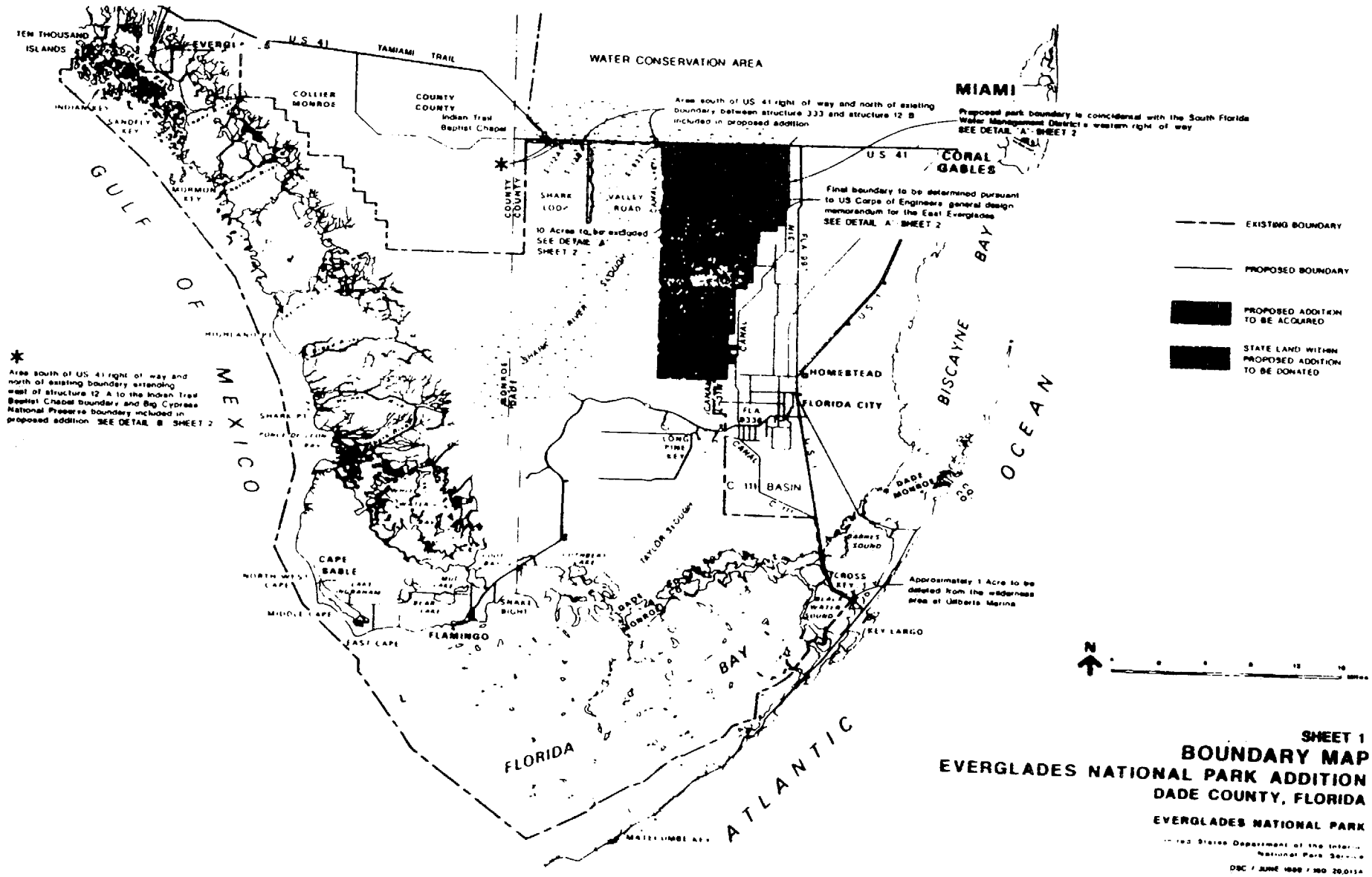


* Area south of US 41 right of way and north of existing boundary extending west of structure 12 A to the Indian Trail Baptist Chapel boundary and Big Cypress National Preserve boundary included in proposed addition SEE DETAIL 'B' SHEET 2

SHEET 1

BOUNDARY MAP

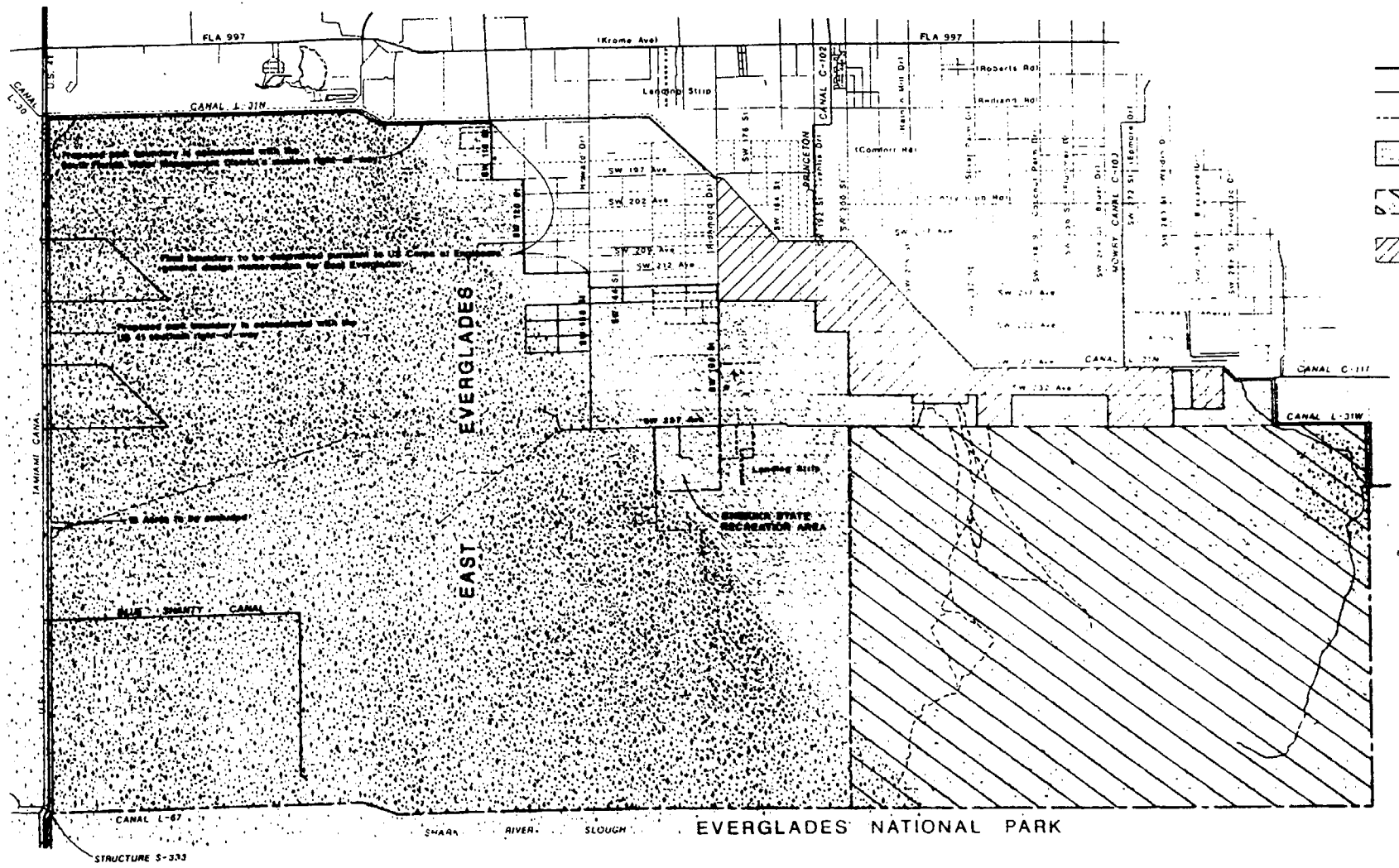
EVERGLADES NATIONAL PARK ADDITION

DADE COUNTY, FLORIDA

EVERGLADES NATIONAL PARK

United States Department of the Interior
National Park Service

DSC / JUNE 1980 / 380 20,011A


EXISTING BOUNDARY
PROPOSED BOUNDARY
BIG CYPRESS NATIONAL PRESERVE
PROPOSED ADDITION TO BE ACQUIRED
STATE LAND WITHIN PROPOSED ADDITION TO BE DONATED
AGRICULTURAL AREA
FLA 997
(Krome Ave)
CANAL L-31N
CANAL L-30
TAMIAMI CANAL
EAST EVERGLADES
Landing Strip
CANAL C-102
(Roberts Rd)
(Coomer Rd)
SW 197 Ave
SW 202 Ave
SW 207 Ave
SW 212 Ave
SW 152 St
SW 216 St
SW 232 St
SW 237 Ave
SW 137 Ave
SW 117 Ave
SW 107 Ave
SW 97 Ave
SW 87 Ave
SW 77 Ave
SW 67 Ave
SW 57 Ave
SW 47 Ave
SW 37 Ave
SW 27 Ave
SW 17 Ave
SW 7 Ave
SW 132 Ave
SW 137 Ave
SW 142 St
SW 152 St
SW 157 St
SW 167 St
SW 177 St
SW 187 St
SW 197 St
SW 207 St
SW 217 St
SW 227 St
SW 237 St
SW 247 St
SW 257 St
SW 267 St
SW 277 St
SW

EIS APPENDIX B

EXECUTIVE SUMMARY

TROPICAL BIOINDUSTRIES, INC.
REPORT ON
HYDROPERIOD CONDITIONS OF
KEY ENVIRONMENTAL INDICATORS OF EVERGLADES NATIONAL PARK
AND ADJACENT EAST EVERGLADES AREA AS GUIDE TO
SELECTION OF AN OPTIMUM WATER PLAN FOR
EVERGLADES NATIONAL PARK, FLORIDA

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

HYDROPERIOD CONDITIONS OF KEY ENVIRONMENTAL INDICATORS OF EVERGLADES NATIONAL PARK AND ADJACENT EAST EVERGLADES AREA AS GUIDE TO SELECTION OF AN OPTIMUM WATER PLAN FOR EVERGLADES NATIONAL PARK, FLORIDA

EXECUTIVE SUMMARY

March, 1990

Tropical BioIndustries, Inc.
7821 S. W. 114th Street
Miami, Florida 33156

The Study Area. The study area is located in Dade and Monroe Counties, Florida. It is bounded on the north by the Tamiami Trail (U. S. Highway 41); on the east by L-31(N), L-31(W), and the C-111 canal axis; on the west by the western extent of hydrologic influence of water management alternatives; and on the south by the Park boundary in Florida Bay. This area contains two different management-administrative entities, the Everglades Sector of Everglades National Park, and its neighbor to the east, the East Everglades.

Scope of Work. The service to be rendered under this contract included (1) Selection and quantification of existing conditions of important ecological resources of the two study areas that would be affected over the short-term or long-term by changes in the delivery of water (spatial, temporal, and volumetric) through Shark River Slough, Taylor Slough, and the C-111 levee. Those resources were to be used as KEY ENVIRONMENTAL INDICATORS indicative of the "health" of the Park and East Everglades; (2) Develop and document the relationship of the condition of the KEY ENVIRONMENTAL INDICATORS to the hydrologic regime of the two study areas; (3) Develop an OPTIMUM HYDROPERIOD for the KEY ENVIRONMENTAL INDICATORS; and (4) Access the impact of alternative plans of water management on the KEY ENVIRONMENTAL INDICATORS. Originally, four such plans had been advanced for consideration, but when the National Park Service opted for the Modified Rain-Driven Plan with Residential Flood Protection, the assessment was done for that plan.

Selection and Quantification of Important Ecological Resources. This aspect of the investigation involved the listing of nearly 3,000 species of plants and animals, life history data, and habitats. For example, the 357 species of vertebrate animals in the East Everglades tended to occur in four "distinct wildlife sub-areas", the Northeast Shark River Slough, the Rocky Glades, the Southern Coastal Glades, and Disturbed Land. Within those four sub-areas, 8 habitats were listed. These were (1) Marsh, (2) Prairies, (3) Cypress, (4) Hammocks, (5) Disturbed, (6) Mangroves, (7) Ponds, and (8) Thickets.

Within these 8 habitats were more than 45 recognizable plant associations. Similarly, the Park fauna occupies 13 habitats as follows: (1) Pine Forest, (2) Hammock Forest, (3) Cypress Forest, (4) Mixed Swamp Forest, (5) Inland Marshes, Ponds and Sloughs, (6) Prairies, (7) Coastal Mangrove Forests, (8) Coastal Marshes, (9) Saltwater Prairies or Marshes, (10) Florida Bay Submarine Meadows, (11) Gulf of Mexico Level Bottom Nearshore Shallows, (12) Florida Bay Keys, and (13) Disturbed Land.

The East Everglades contains a known 6 federally listed endangered, and 2 threatened species of animals, the Everglades or Snail kite, Peregrine falcon, Florida panther, American crocodile, Cape Sable seaside sparrow, Bald eagle as endangered and the American alligator and Indigo snake as threatened. A substantial part of the Critical Habitat of the Cape Sable seaside sparrow lies in the East Everglades as well as a small portion of such habitat for the American crocodile.

The fauna of the Park study area contains nearly 1,500 listed species of animals of upland, freshwater, brackish-water, and marine affinities. Among these are 6 federally listed endangered reptiles, 5 of birds, and 2 species of mammals as well as many others listed by the Florida Game and Fresh Water Fish Commission (Table 1). Officially designated Critical Habitat of the Everglades or Snail Kite, the Cape Sable seaside sparrow, and the American crocodile occupy large portions of the Park Study area.

The flora of the Park study area contains 959 species of vascular plants. Of these, 220 are introduced species. In addition, there are more than 400 species of algae of fresh and brackish-water, and 60 species of macroscopic green, brown and red algae. So far as could be determined, the East Everglades study area flora is identical to that of the Park upland and freshwater habitats, but contains no saline or brackish-water habitats, hence is more limited as to variety. The East Everglades also contains fewer endemic plant

Table 1. Threatened and Endangered Species and Species of Special Concern known or expected to occur occasionally in Everglades National Park study area (from Wood, D. A., July 1, 1987, and Florida committee on Rare and Endangered Plants and Animals of Florida. Pritchard, ed., 1978-79)

Common Names	FCREPA	FGFWFC	USFWS	CITES
FISH				
Common snook		SSC		
Rivulus	T	SSC		
Tidewater silversides	SU			
AMPHIBIANS AND REPTILES				
American alligator	SSC		T(S/A)	
Atlantic loggerhead sea turtle	T	T	T	I
Atlantic green sea turtle	E	E	E	I
American crocodile	E	E	E	I
Leatherback sea turtle	R	E	E	I
Eastern indigo snake	SSC	T	T	
Atlantic hawksbill sea turtle	E	E	E	I
Gopher tortoise	T	SSC	UR2	
Atlantic Ridley sea turtle	E	E	E	I
Rimrock crowned snake	T	T	UR2	
BIRDS				
Roseate spoonbill	R	SSC		
Cape Sable seaside sparrow	E	E	E	
Limpkin	SSC	SSC		
Swainson's hawk			UR2	
Southeastern snowy plover		T	UR2	
Marsh hawk; American harrier				II
White-crowned pigeon	T	T		
Little blue heron	SSC	SSC		
Reddish egret	R	SSC		
Snowy egret	SSC	SSC		
Tricolored heron; Louisiana heron	SSC	SSC		
Swallow-tail kite			UR2	
Pigeon hawk; merlin	SU			II
Arctic peregrine falcon	E	E	T	I
Eastern kestrel				II
Florida sandhill crane	T	T		II
American oyster catcher	T	SSC		
Bald eagle	T	T	E	I
Wood stork	E	E	E	
Osprey	T	SSC	SSC	
Brown pelican	T	SSC		
Crested caracara	T	T	T	

Table 1. cont.

Common Names	FCREPA	FGFWFC	USFWS	CITES
Mangrove clapper rail	SU		UR2	
Snail kite	E	E	E	
Least tern	T	T		
Roseate tern	T	T	T	
Backman's warbler	E	E	E	
MAMMALS (exclusive of bats)				
Sherman's short-tailed shrew	SU	SSC	UR2	
Florida panther	E	E	E	I
River otter				II
Bobcat				II
Everglades mink	T	T	UR2	
Round-tailed muskrat	SSC		UR2	
Big Cypress fox squirrel	E	T	UR2	
West Indian manatee	T	E	E	
Florida black bear	T	T	UR2	
INVERTEBRATES				
Florida leafwing butterfly			UR2	
Florida otala butterfly			UR2	
Florida tree snail; *Lignus*		SSC		

LEGEND

SU	=	Status Undetermined
SSC	=	Species of Special Concern
T	=	Threatened
T(S/A)	=	Threatened due to Similarity of Appearance to other crocodilians harvested by commercial hunters
R	=	Rare
UR	=	Under Review for federal listing with substantial evidence indicating at least some degree of biological vulnerability and/or threat
UR2	=	Under Review for listing, but substantial evidence of biological vulnerability and/or threat is lacking
E	=	Endangered
FCREPA	=	Florida Committee on Rare and Endangered Plants and Animals
FGFWFC	=	Florida Game and Fresh Water Fish Commission
USFWS	=	United States Fish and Wildlife Service
CITES	=	Convention on International Trade in Endangered Species

species because the pineland habitat where most endemics are found in limited extent there. Introduced Melaleuca trees are much more common in the East Everglades where hydroperiod change has been most severe.

Wetlands are critically important resources in both study areas. Excluding open water of coastal bays, ponds, and larger river channels, the Everglades National Park study area covers an estimated 682,000 acres of nominal mainland. This is about 27 percent of the estimated 2,496,000 acres contained in the original Everglades Basin south of Lake Okeechobee. The East Everglades study area lying north of the south end of L-31(W) canal contains about 132,213 acres or 5.3 percent of the Basin total acreage. It was estimated that all but 26,894 acres or 3 percent of the Park study area and 2,874 acres or one percent of the East Everglades study area were originally wetland on the basis of soil type, vegetation cover, and relation of the water table to the ground surface.

Of the 682,000 acre total mainland acreage in the Park study area, about 321,294 acres or 47 percent of these wetlands were, and still are, influenced by saltwater. The remaining wetlands, all freshwater types, are divisible as follows: Peatlands 77,398 acres (11 percent), Marllands or Marl Prairies 225,214 acres (34 percent), and Hydric Rockland 31,398 (5 percent). A substantial acreage of a fourth wetland type called Gandy Peat of Bay tree heads occurs but has not been estimated because it is scattered in hundreds of sites throughout the other three major wetland soil-plant associations and because more than 70 percent of the original Gandy peat deposits and their associated tree and shrub growths have been wholly or partly destroyed by wildfire during droughts of the 1960's, 1970's, and 1980's. Such loss was especially severe in the Pinnacle Rocklands of both study areas causing a severe degradation of the original grassland-tree island scenery there.

Adding the above acreages of the three principal freshwater wetland soil-vegetation types in the Everglades sector gives a total of

freshwater wetlands of 333,818 acres which is about 14 percent of the 2,296,000 acres of wetlands once contained in the Everglades Basin. If the hydric rockland (31,398 acres) and marl prairies (225,214 acres) are deleted from the total as being "peculiar" to the area south of the Tamiami Trail, and consider only the freshwater peats as being "typical" of the original Everglades Basin, then the Park contains only 3.1 percent of the original Everglades Basin wetlands.

Of the 132,213 acres in the East Everglades lying north of the southern end of Canal L-31(W), Everglades freshwater peats of the Northeast Shark River Slough cover 51,122 acres, marls of the Taylor Slough headwater marsh cover 18,477 acres, and hydric rockland or pinnacle rocklands cover 56,150 acres. Still assuming that Everglades peats are the only true indicators of extent of typical Everglades Basin vegetation and habitat conditions, then the 51,122 acres of peats in the Northeast Shark River Slough of the East Everglades when added to the 77,398 aces of such peat in the adjacent slough in the Park give a combined total of 128,520 acres of peatlands or about 5 percent of the total Everglades Basin wetland habitat which was so important to the productivity of regional wildlife populations.

Selection of Key Environmental Indicators. For reasons developed in the body of this report, the hydric soils of the study area, freshwater peats and marls, were selected as Key Environmental Indicators. With animals, even those as well-known as wood storks, alligators, white-tailed deer, and Everglades bullfrogs, our understanding of limiting factors on their "prosperity" is incomplete. Furthermore, their mobility and adaptability to change seems rather high. For such animals their presence in an area today doesn't tell us much about where the species was a decade or a century ago, a statistic which is useful if we have a hope of restoring damaged habitat. Presence of hydric soil deposits on the other hand, even if in a badly decayed or otherwise altered state, tells us instantly what conditions were for deposition and how, given the opportunity, to restore damaged habitat. This is so because the

habitat requirements of the peat and marl forming "parent plant" communities are known with fair precision.

Hydroperiod. On the basis of this fundamental decision, the ideal or Optimum Hydroperiod of the hydric soils was sought in the literature and from personal research and observational experience. It was concluded that in most years the peats were deposited under conditions of near-permanent flooding by water ranging in depth from the peat surface to two feet above. During the dry seasons, the water table might recede a foot below the surface, but only for about a month and surface peats would then remain saturated due to capillary connection with the underlying water table. In exceptional floods such as that of 1947, depth might even exceed two feet for brief intervals without damage to the parent plant community, while depression of water level more than one foot below the peat surface could and did occur, but only in very severe drought, and slough plants were able to recover quickly from buried tubers, seeds and other "resting" structures.

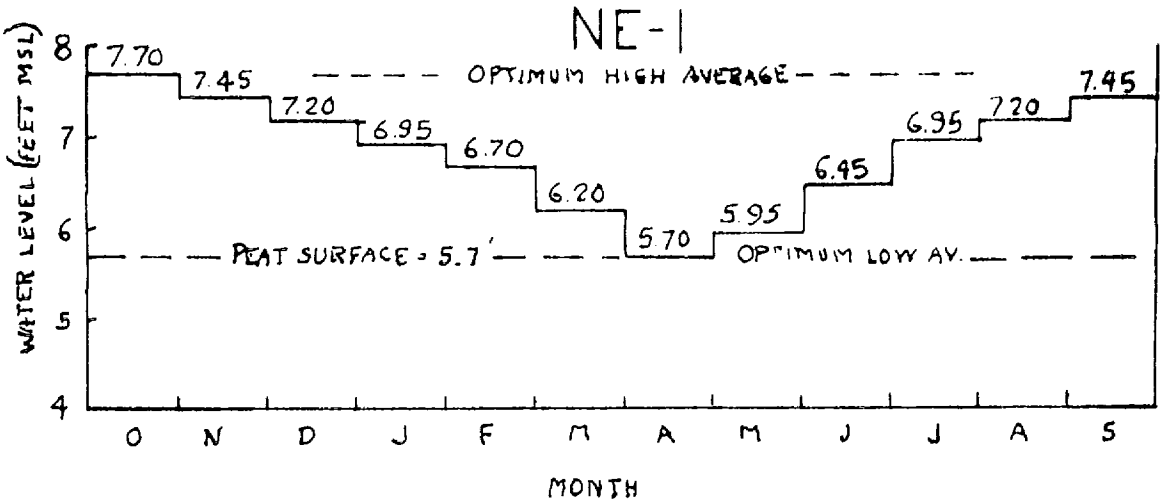
Marl is formed by a "periphyton" community of filamentous bluegreen algae under conditions of surface inundation as shallow as 2 to 3 inches for 4 months, to 2 to 21 inches deep for 12 months. However, optimum depth and duration of flooding is about 9 inches for about 7 to 10 months. Periphyton will persist as a green to blue-green "felty" mat on the marl surface so long as capillary contact is maintained between the marl and the water table, but it will not form marl in the absence of prolonged periods of standing or slowly flowing water containing calcium carbonate in solution. Where the water table recedes from the marl overburden into underlying limestone, capillarity will be lost and the marl becomes one of the most droughty soils in Florida. If this condition occurs often due to regional drainage as in the Taylor Slough headwater marsh, thin marl deposits, the dominant original sparse sawgrass is rapidly replaced by Muhly grass which is ideally suited to life in droughty marl soil when dampened by local rain showers. Muhly does not flourish under long-term shallow surface flooding.

Peats and marls indicate, by their present distribution, where the above described water depths and duration conditions have occurred for centuries. Additionally, because they were deposited on slowly rising water table under geologically recent rising sea level conditions, they are also indicators of the long-term balance between seawater and fresh in the aquifer.

Where periphyton and resultant marl deposits are being formed on top of Everglades and Loxahatchee peat, as is now the case in the Northeast Shark River Slough, this is powerful evidence that average water depth there has receded from its 2 foot average annual maximum flood depth required by peat-forming slough plants to the 9 inch average annual maximum depth considered optimal for periphyton. This is also indirect evidence that fish populations are changing in favor of small species at the expense of the sunfish, bass, garfish, and bowfin as well as alligators and other animals which are the dominant species of sloughs.

Assessment of the Effects of the Modified Rain-Driven Plan. The rain-driven water management alternative promises to restore sheet flow across the entire Tamiami Trail front of both the Park and East Everglades study areas as was the case prior to diversion and completion of the Water Conservation Area 3A and 3B. The data provided by the south Florida Water Management Model also indicates that there may be sufficient supplemental water in most years to provide the depth required by the above analysis of hydroperiod. To test this, Well NE-1 in the Northeast Shark River Slough has been selected as "master well" for monitoring. Peat surface elevation at NE-1 is 5.7 feet above sea level. Thus, to conform to the optimum hydroperiod for peat-forming slough plants, water level should, ideally, fluctuate between 5.7 and 7.7 feet annually and in a pattern suggested by Figure 1A. Such fluctuation would provide the majestic lateral movement of water in the Slough up and onto the adjacent ridges of pinnacle rockland in summer and fall, followed in winter and early spring by a matching slow recession down gradient in all

Figure 1A. Average Monthly Optimum Water Heights at NE-1 (SFWMD Model Grid Column 22, Row 20)



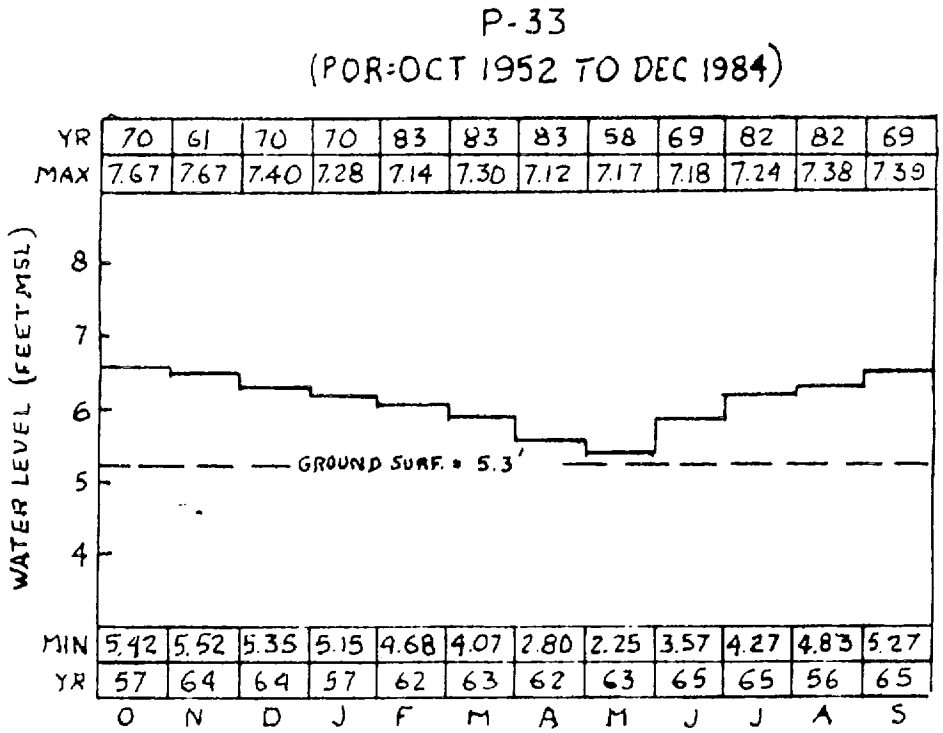


Figure 1B. Constructed Optimum Hydroperiod for Well NE-1 compared with observed condition at NPS Well P-33.

directions to the low point in April or May. Average monthly change in elevation of surface water at Well P-33 in the Park sector is shown in Figure 1B by comparison.

One of the attractive aspects of the plan of restoration lies in the reinstatement of flow to Conservation Area 3B, a move which will tend to retard the velocity by which Everglades Basin water reaches the Tamiami Trail. This plus the greater area in the Northeast Shark River Slough can accept large amounts of water with minor fluctuations in depth. This will tend to minimize the extreme fluctuations caused by emergency flood releases from the S-12 structures into former marl prairie land that normally had maximum seasonal high water depths of about 9 inches indicated by the thin deposits of Ochoppee Marl at that location.

By restoring sheet flow across the whole north front of the system between L-31(N) on the east, to 40-mile Bend on the west, and thus restoring the lateral flexing of the system, groundwater flow and recharge of the Biscayne Aquifer to the east will be maximized and the former high water connection between the Northeast Shark River Slough and the pitted oolite of the Taylor Slough headwater marshes should be restored to benefit Taylor Slough. The degree to which this may happen must be measured at a number of existing wells, but Well NE-1 is believed to be "key" to monitoring.

Conclusion. If the above described working hypotheses are correct, and the optimum hydroperiod approached with reasonable fidelity in as many as 7 out of 10 years, all of the living resources of the Park and East Everglades should begin to revert back to something like the original state of species richness, diversity, and productivity. Rainfall has not changed, only the way that supplemental water is brought to the Park, and habitats outside the study areas have changed and the plan offers a promise of significant remedial action in the rate and place of water delivery. The one worrisome aspect of the plan remains the water-wasting character of the L-31(N), L-31(W) and C-111 canal system which is dedicated to permanent draw down of

water in its zone of influence to a minimum of 18 inches below ground surface in order to protect agricultural crops in lowest elevation lands there. This exerts a permanent impact out to the west in the Park and East Everglades on an area 3 or more miles wide. Perhaps the restoration of higher groundwater originating from higher water in the Northeast Shark River Slough will steepen the gradient from west to east toward the canal and retard the westward spread of Melaleuca, Australian pine, and other exotic species.

Other Unresolved issues.

The Modified Rain-Driven Plan is responsive to most of the needs of Everglades National Park, but several issues remain unresolved. The plan does nothing to resolve the problem of uncontrolled flood releases from C-111 canal created by the strict requirement for flood control in South Dade County low-lying farm land adjacent to the Park. In addition, it is not possible to predict, even given ideal hydroperiod conditions, whether there is sufficient food-producing aquatic animal habitat left in the Park and East Everglades to allow restoration of Park wading bird populations to pre-1960's levels. Only time will tell. Finally, while restoration of flow through Conservation Area 3B marshes will probably do much to remove excess particulate matter and nutrients originating as runoff from the Everglades Agricultural Area, it is likely that this will be effective for only a brief period of time before nutrients, especially phosphorous, will exceed the 0.02 ppm considered normal for pristine Everglades marsh waters. Even local tourist centers along the Tamiami Trail and in the Park itself cause large increases of phosphorus. How much more serious this problem will be due to large agricultural area inputs is conjectural and can only be determined by monitoring.

EIS APPENDIX C

PROCEEDINGS OF A WORKSHOP FOR ANALYSIS OF ENVIRONMENTAL BENEFITS TO EVERGLADES NATIONAL PARK FROM HYDROLOGIC RESTORATION OF SHARK RIVER SLOUGH

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Central and Southern Florida Project

Part 1, Supplement 54

ANALYSIS OF ENVIRONMENTAL BENEFITS TO EVERGLADES NATIONAL PARK FROM HYDROLOGICAL RESTORATION OF SHARK RIVER SLOUGH

PROCEEDINGS OF A WORKSHOP CONDUCTED
BY THE U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT
11-13 MAY 1987

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I. INTRODUCTION

At an April 1987 meeting between Colonel Charles Myers (District Engineer, Corps of Engineers, Jacksonville), John Wodraska (Executive Director, South Florida Water Management District), and Michael Finley (Superintendent, Everglades National Park), it was suggested and agreed that a workshop be held to develop a consensus on the potential environmental benefits to Everglades National Park of changes in the existing hydrologic conditions within Shark River Slough. They decided that the workshop would be an intensive 3 or 4 day invitational meeting of individuals who had extensive Everglades research experience. The product of the workshop would be a so-called "white paper" reflecting the participating experts' analysis and synthesis of existing data and, where necessary, professional opinion developed in an interactive environment. The Corps conducted the workshop in Homestead, Florida, on 11-13 May 1987. A list of attendees and their affiliation is shown in table 1. The participants were formed into sub-groups to write up evaluations for specific environmental resources that were ecologically important and had the potential to be affected by modification of hydrologic conditions. These write-ups constitute the main body of this document and are reproduced verbatim in subsequent sections. The authors of each write-up are solely responsible for the content, and, since they are considered to be the experts in their field, they were given the final discretion to accept or reject any substantive comments made during subsequent reviews. These proceedings will serve as a major source document for preparation of the Corps' Environmental Impact Statement accompanying the General Design Memorandum on Modified Water Deliveries to Everglades National Park.

TABLE 1. LIST OF PARTICIPANTS

Name	Agency/Organization*
Lance H. Gunderson**	Everglades National Park
Gary Y. Hendrix, Ph.D.	Everglades National Park
William F. Loftus	Everglades National Park
William B. Robertson, Ph.D.	Everglades National Park
James T. Tilmant**	Everglades National Park
Bradley G. Waller	U.S. Geologic Survey
Arnold Banner, Ph.D.	U.S. Fish and Wildlife Service
Joan A. Browder, Ph.D.	National Marine Fisheries Service
Steven M. Davis	South Florida Water Management District
David R. Swift	South Florida Water Management District
Richard M. Cooper	South Florida Water Management District
John W. Ault, III	Florida Game and Fresh Water Fish Commission
John C. Ogden**	National Audubon Society (now with ENP)
George V.N. Powell, Ph.D.	National Audubon Society
George H. Dalrymple, Ph.D.**	Florida International University
Ronald H. Hofstetter, Ph.D.	University of Miami
Durbin C. Tabb, Ph.D.	Tropical BioIndustries, Inc.
Lewis I. Hornung	U.S. Army Corps of Engineers
Jonathan D. Moulding, Ph.D.	U.S. Army Corps of Engineers

*Listed for affiliation purposes only.
**Sub-group leader

serves as the primary source of overland flows into ENP. WCA No. 3 was designed, in part, to enable water to be stored and used, when needed, to meet water requirements of developed areas and ENP. It was recognized that the plan could not fully satisfy all water demands of future development and ENP, but it was felt that a plan to satisfy such future demands would be beyond the scope of the authorizing document.

In February 1968, the Survey Review Report--Water Resources for Central and Southern Florida addressed regional water supply problems in the C&SF Project. Recommendations of this report were authorized by Public Law 90-483 in August 1968. The recommended plan included a system of conveyance canals to supply water from WCA No. 3A to ENP and south Dade County developed areas. Water supplied to ENP as a result of the recommended plan was considered to be a general benefit and a Federal responsibility. Therefore, the Federal Government paid 100 percent of the construction costs of all necessary project modifications for water deliveries to ENP. Furthermore, operation and maintenance costs of the conveyance system works for water deliveries to the park currently are being Federally funded.

Public Law 91-282, dated June 1970, guaranteed a minimum supply of water deliveries from the C&SF Project to ENP specified on a monthly basis for Shark River Slough, Taylor Slough, and the eastern panhandle area.

Public Law 98-181, dated November 1983, authorized a 2-year experimental program of modified water deliveries to ENP for the purpose of determining an improved method for such deliveries. In addition to enabling the field testing of alternative water delivery methods, this authorization led to preparation of a General Design Memorandum addressing designs and cost estimates for necessary modifications to C&SF Project work for improved water deliveries. Public Law 99-190, dated December 1985, authorized extension of the experimental program until January 1989.

C. Deficiencies in the Existing Water Delivery System.

The development of an improved water delivery method must address three issues; timing, location, and volume. In general, the goal is to provide a water delivery system that allows hydrologic conditions in the Everglades to fluctuate in a manner similar to what occurred under natural conditions. This includes wide variation from year to year between extremes of flood and drought. Unfortunately, there are not sufficient data available to define natural hydrologic conditions with an adequate degree of detail. A description of hydrologic problems associated with the water delivery procedures prescribed by PL 91-282 and the existing physical system follows:

1. Timing. According to operating criteria used for implementation of PL 91-282, water deliveries are provided at rates close to the minimum monthly requirements under most conditions. This provides a uniform water delivery schedule with little variation unless there are extreme flood or drought conditions in WCA No. 3A. If water levels in WCA No. 3A rise above the regulation schedule, it becomes necessary to increase the water delivery

III. HYDROLOGIC OBJECTIVES OF AN IMPROVED WATER DELIVERY SYSTEM

A. General. The overall objective of the GDM is to improve environmental conditions within ENP to the extent possible through changes in the water delivery system. To accomplish this, the physical water management system must provide increased overland flow, the integration of WCA No. 3B into the Everglades hydrologic system, the restoration of flows through Northeast Shark River Slough, and the continuation of testing and adjusting of the system's operation to develop an optimum schedule with respect to the timing and volume of water deliveries. Additionally, measures must be taken to ensure that the authorized function of the C&SF Project or adjacent interests are not adversely impacted. Table 2 describes the hydrologic objective(s) for which each structural modification is being considered. Specific modifications being considered and their purposes are described below:

TABLE 2

	Integration of WCA No. 3B into Everglades System	Restoration of Flows to NESRS	Increase Overland Flows	Avoid Adverse Impacts on C&SF Project Functions or Adjacent Lands
S-349	X		X	
S-345	X	X	X	
S-355	X	X	X	
Seepage Control Measures				X
Modification L-67 Ext.		X	X	
East Everglades Flood Protection and/or Acquisition				X
Miccosukee Indian Camp Flood Proofing or Relocation				X

B. S-345 A, B, and C. Three sets of gated culverts would be placed at about 6,000-ft. intervals along L-67A between S-151 and S-333. Each set of culverts would have a capacity of about 500 cfs. Water discharged through the culverts would be conveyed into WCA No. 3B via discharge canals with containment levees between L-67A and L-67C.

IV. POTENTIAL ECOLOGICAL IMPROVEMENTS

A. General.

The workshop participants developed the following guidance for formatting their write-ups. The historical condition of the environmental resource would be described as fully as possible. The historical period was defined as the mid-1930's based on the ENP implementing legislation of May 1934 that provided a mandate to preserve the "primitive conditions now prevailing". The historic condition would be the target for improvements for future actions. This was also a means of avoiding the "optimization" problem of having to subjectively prioritize improvements for various ecological entities if their hydrologic requirements differed. Where possible, existing conditions would be quantified based on research data. Projections of future conditions were premised on full restoration of historical hydrologic conditions. No attempt was made to focus on a particular plan of restoration. It was recognized that some portions of the decline of particular environmental resources could be due to factors extrinsic to the hydrologic regime within Shark River Slough (e.g., loss of wetlands through development). Complete environmental restoration would not be possible with that situation. The Federal interest was defined as environmental improvement in the Park, not improvement outside the Park per se (e.g., Northeast Shark River Slough). Improvements outside the Park boundary would be relevant to a Federal benefits analysis only as they might secondarily improve conditions in the Park. Participants were encouraged to include their thoughts on the environmental monitoring that would be necessary over the long-term to determine if any changes in hydrologic conditions were resulting in environmental improvement in the Park, and the time-frame expected for such improvement to take place. The following sections reproduce verbatim the individual write-ups. Organizational listing is for affiliation only; the work represents solely the views of the individuals.

WOOD STORKS, WADING BIRDS, AND FRESHWATER FISHES

John C. Ogden, William F. Loftus,
and William B. Robertson, Jr.

I. Historical

Wading birds - 1930's to 1960

The best numerical data for wading birds in the region of southern Florida presently occupied by Everglades National Park (ENP) are for Wood Storks (Table 1). Although the numbers are somewhat debatable, our current opinion is that the stork nesting colonies in ENP during the 1930's contained approximately 2,000 to 4,000 pairs in most years. From that decade until 1960, declines in the ENP breeding population of Wood Storks occurred slowly, apparently in response to gradual losses in total area of wetlands in the southern Everglades (Browder et al. 1976). For seven years with reasonably complete data between 1948 and 1960, the mean number of breeding pairs per year in ENP was 2,370 (range = 600-3,000). The rate of successful nesting was relatively high in comparison with more recent rates, with large numbers of young storks being produced in 6 of 7 years during the 1940's, and in 5 of 10 years during the 1950's (Ogden and Patty 1982).

Considerably less precise data on population sizes and trends for the other principal nesting wading birds of the interior Everglades (egrets, herons, White Ibis) are available during the 1930 to 1960 period (Robertson and Kushlan 1974, Ogden 1978, Frederick and Collopy 1987). Almost all large nesting colonies reported during those three decades were located at the extreme lower end of the Everglades in the Shark River Slough drainage, either at the coastal mangrove/marsh zone (including the Cape Sable peninsula) or along the headwater creeks of Lostmans, Broad, and Shark rivers. The zone of freshwater marshes adjacent to the mangrove edge between Lostmans and Shark River headwaters was the major feeding area for waders in the southern Everglades during the nesting season (Allen 1958). A single, mixed-species nesting colony at Rookery Branch in the lower Shark Slough in 1934 was estimated to contain a minimum of 250,000 pairs, mostly White Ibis (Allen 1958; but estimated at only 225,000 birds by Warden L.R. Roberts, 20 March & 28 April 1934). A colony located at the same site in 1940 contained an estimated 60,000 nests (Sprunt 1940). By 1960, the total Everglades population of all species of nesting waders was estimated at 150,000 pairs of birds (Robertson and Kushlan 1974).

Wading birds - 1960's and 1970's

This 20-year period was one of transition for the ENP Wood Stork breeding population. The most significant change was in the timing of nesting, with a shift from the historical pattern

of colony formation during November and December in most years, to a pattern of colony formation January and March (Kushlan et al. 1975, Ogden and Robertson, unpubl. data). Between 1953 and 1959, stork colonies in ENP began forming in November in 3 years, in December in 7 years, in March in 1 year, and failed to form in 1 year (1962). Four of the 8 years of November-December formation were successful, while the March year was a failure (Ogden, unpubl. data). Overall, for the 1960's, storks nested successfully in only 4 of 10 years. Population decline continued, with an 8-year mean of 1,930 breeding pairs (range = 200-3,700).

During the 1970's, late colony formation by storks became routine. Colonies formed as early as December only in 1976, and in only 2 of 10 years in this decade (both years when colonies formed in early January) was nesting successful. Colonies formed during January in 5 years, and in February-March in 4 years. Because of late formation, colonies often were still active when rains began in May or June. With rising water levels, adults were unable to collect enough food, and young were abandoned in the nests. The rate of population decline for Wood Storks sharply accelerated during the 1970's. The mean annual breeding population between 1970 and 1979 was 875 pairs (range = 290-1,235).

Population trends for the other species of nesting waders in the southern Everglades during these two decades closely followed the pattern shown by storks. Robertson and Kushlan (1974) estimated a 50-percent reduction in the total wader breeding population in the Everglades between 1960 and 1970 (down to 75,000 pairs). A survey of active wading bird colonies during 1974-75 revealed an estimated 11,000 total pairs of the key Everglades species (excluding Cattle Egrets) nesting in ENP, and about 48,200 pairs for the entire Lake Okeechobee/Everglades region (Kushlan and White 1977).

A significant change in the location of nesting colonies of small herons, egrets, and ibis occurred between the mid-1960's and mid-1970's. These species abandoned the traditional colony sites at the headwaters of Shark, Broad, and Lostmans rivers in ENP; apparantly the same birds moved north to new colony sites in central Water Conservation Area 3A. The cause for this shift is not known, although it closely coincided with the construction of the WCA-3 levees and the S-12 structures which created a large ponded area in the southeastern portion of WCA-3A.

Fish populations

No data, quantitative or otherwise, exist for freshwater fishes in the Everglades before 1960. It is therefore impossible to reconstruct historical fish communities, population structures, or densities. However, several assumptions can be made by considering probable historical water conditions in the

southern Everglades and the success of nesting wading birds in that region.

The Everglades freshwater fish community responds to different sets of water conditions through changes in composition, biomass, and size structure (Kushlan, 1976a, 1980). Population densities and biomass are highest in marshes with seasonally fluctuating water depths and extended hydroperiods (Loftus et al., in press). In marshes with short hydroperiods (less than 11 months), fish densities, biomass, and diversity decline significantly (Loftus et al., in press). Large fish species, especially sunfishes, succeed best under long-hydroperiod conditions (Kushlan 1976a). In marshes with seasonally variable water depths, sunfishes and other large species are normally associated with alligator ponds (Loftus and Chapman, unpubl. data).

In the Everglades, fish recruitment reaches a peak in late summer and autumn and declines during the winter. By February-March, reproduction begins again and, combined with the concentration effects caused by decreasing water depths, fish and macroinvertebrate densities reach high levels. The timing of concentrations depends upon location along the lateral gradient of the sloughs, rainfall, water management releases, and reproductive input (Loftus and Kushlan 1987).

Wading birds utilize fishes and macroinvertebrates as their major prey in Everglades marshes (Robertson and Kushlan 1974, Kushlan 1976b, Ogden et al. 1978). High densities of suitably sized prey must be available in the right water depths throughout the nesting season for wading birds to produce young successfully (Ogden et al. 1978, Robertson and Kushlan 1974, Kahl 1964). Because large numbers of wading birds nested successfully in ENP in many years prior to the 1960's, it must be assumed that fishes and macroinvertebrates were available in sufficient quantities to support this nesting effort. Declines in nesting success began in the 1950's, but accelerated greatly in the 1960's and 1970's. Robertson and Kushlan (1974) suggested that poor nesting success of Wood Storks reflected changed conditions in the highly altered, interior wetland ecosystem of southern Florida.

Anecdotal accounts of the early Everglades explorers (Willoughby 1898, Pierce 1962) suggest that peripheral wetlands were much more extensive, and that the central Shark River Slough held some surface water throughout most dry seasons. Under these conditions, it is likely that as the peripheral areas dried, large areas of edge habitat made fish concentrations available to wading birds. As the drying edges moved towards the central core of the slough, new feeding areas were made available over a prolonged period during the nesting season. It may be that, unlike today, the central valley of Shark River Slough rarely dried completely except during extreme droughts, thus providing a reserve from which fishes could recolonize peripheral marshes after each dry season. Prolonged flooding of the central slough

would have provided the conditions for forming the peat sediments found there, while the increased hydroperiod in peripheral areas would have produced higher total fish and macroinvertebrate populations. The loss of many peripheral marshes, and the degradation of much of eastern Shark River Slough and Taylor Slough, has certainly resulted in the disappearance of organically rich sediments. Current research suggests a strong correlation between the absence of organic substrates and low densities and biomass of fishes and invertebrates (Loftus et al., in press).

II. Present Conditions

Wading birds

Between the late 1970's and 1987, Wood Storks and other waders nesting in mainland ENP experienced perhaps the most rapid rate of decline of any decade in south Florida history. Storks no longer formed colonies as early as December, and they produced small numbers of young in only a few years, primarily in 1981, 1985, and 1987 (table 1). The mean, annual breeding population of storks between 1980 and 1987 was only 374 pairs (range = 15-1,660). Overall reduction of the Wood Stork breeding population in Everglades National Park between the 1930's and 1950's was approximately 20 percent. The population reduction between the 1960's and 1980's has been 80 percent (Ogden et al., 1987).

Total mainland breeding populations for other wading bird species also have reached extreme lows during the 1980's (ENP files, Collopy and Frederick 1986, Frederick and Collopy 1987). Fewer than 2,000 pairs of Great Egrets and 1,500 pairs of Snowy Egrets have nested in mainland colonies of ENP and WCA-3 in most years since 1980. Only 2,500 pairs of White Ibis in 1986 and 5,000 pairs in 1987 nested in the entire area including ENP, WCA-3, and the East Everglades region (Frederick and Collopy 1987).

Fish

In Shark River Slough within ENP, quantitative fish samples have been collected on pull-up traps since 1965 (Kushlan 1980) and by throw trap since 1977 (Loftus, unpubl. data). The results show that fish populations are seasonally and annually variable, being affected by both ambient and antecedent water conditions. Density and diversity are highest during extended high-water periods without severe dry-down (Loftus et al., in press). However, high water conditions without seasonal fluctuations do not make fishes available to wading birds.

Sampling of aquatic animals in Northeast Shark Slough (NESS) revealed densities that were approximately 30 percent lower than those in the Shark Slough marshes within ENP (Loftus et al., in press). These lower densities were attributed to the long-term reduction of hydroperiods in NESS marshes since 1962. This reduction has resulted in the deposition of a layer of marl

(Calcium carbonate) on top of the original peat substrate of the NESS marshes (Loftus et al., in press), which is indicative of a change in the periphyton community (Browder et al. 1981).

Taylor Slough marshes also have a reduced hydroperiod under present conditions. Fish densities are low throughout the Taylor Slough system when compared with long-hydroperiod marshes in the Shark Slough (South Florida Research Center Staff, 1979).

Exotic fishes were not known in the southern Everglades prior to the early 1970's (Loftus, in press). Today, seven species occur in ENP, but only three are locally common (Loftus, in press). In Shark River Slough, exotic species are uncommon and not widespread. However, in the East Everglades where hydroperiods have been reduced, exotic fishes are proportionally more abundant. Loftus and Kushlan (1987) stated that the greater abundance of exotic species in disturbed areas was related to the difficult aquatic conditions imposed on native species there. Reduction of hydroperiod in Everglades marshes may make the marshes more susceptible to invasion by exotic fishes. Although exotic fishes may be preyed upon by wading birds, the long-term contribution or exotics on the total fish biomass remain unknown. Certainly exotic fishes are not desirable additions to the fauna of a national park.

III. What Went Wrong

The Wood Stork seems to be an appropriate indicator of general wading bird population trends in the interior southern Everglades. Because the stork's specialized feeding technique requires high concentrations of small fish in shallow water, it is especially sensitive to events that alter water levels and thus influence the timing of nesting and availability of fish. In addition, a longer, more accurate record of numbers and colony locations exists for Wood Storks than for any other wading bird species in the southern Everglades. Although population data are less precise for other key species, all have shown recent population trends that approximately parallel that of the stork.

Table 1 shows the course of decline of the breeding population of Wood Storks in Everglades National Park by decades from the 1930's to the present; Table 2 gives a rough chronology of the changes of status of all wading bird nesting populations in relation to the salient effects of water control measures upon wading bird habitat in the southern Everglades. Although the data are more complete for Wood Storks, the picture is essentially the same for all nesting populations that depended primarily upon foraging in interior marshes of the region. From peaks in the 1930's local nesting populations declined slowly through the 1950's and more rapidly during the 1960's, and then crashed in the years since 1970. The current level for most species is estimated at roughly 10 to 20 percent of the base that existed when ENP was authorized (1934). The proportion of the decline attributable to shifts by waders to nesting locations

outside of the southern Everglades is unknown, but net loss to the Park has been approximately 85 percent of the total nesting population of wading birds originally supported by the interior wetlands.

The slower rate of decline prior to the 1960's was probably due to the loss of shorter-hydroperiod wetlands peripheral to central Shark Slough that formerly provided important early-dry-season foraging habitat, as well as buffer habitat at times of high water, and to the increased frequency of system-wide drought. The catastrophic rate of decline since 1970 was exactly coincident with and almost certainly the result of the system of water delivery to ENP that prevailed during this period.

The ideal hydrological pattern for Wood Storks, historically, may have been one that maximized wet season water levels and produced moderate and uninterrupted drying from October-November (end of rains) through the dry season (Robertson 1964, Kushlan et al. 1975). Between 1953 and 1962, storks nested successfully in years that had relatively high autumn (OctoberNovember) water levels at P-33, and that lacked excessive drying during the winter/spring months (table 3). During this period, stork colonies usually formed during months that were historically normal for the population of extreme southern Florida (November-December) regardless of the rate of drying at P-33 early in the dry season (November-January; table 4).

For the period between 1963 and 1975, a quite different water level pattern produced the only successful stork nestings. Although successful and unsuccessful nesting years had similar October-November mean water levels at P-33 (6.52 feet and 6.54 feet, respectively), successful years showed much greater high to low ranges between October-November and the following spring (1.77 feet and 1.09 feet, respectively; table 3). Colony formation occurred early (normal) in years of relatively rapid drying early in the dry season (November-January), and occurred unusually late in years of poor early-dry-season drying (table 4). Thus, this period contrasted with the earlier period in that the dryer winter-spring years became the years of nesting success, and the timing of colony formation became regulated by the amount of early-dry-season drying.

The relationships changed again during the generally wetter period, 1976-1987. Again, the successful (only 1981, 1985, 1987) and unsuccessful nesting years had similar October-November mean water levels at P-33, and the successful years again tended to have greater high to low ranges than did the unsuccessful years (1.00 feet and 0.69 feet, respectively; table 3). Colonies during this period usually formed late (February-March in 8 of 12 years) regardless of the amount of drying at P-33 early in the dry season (table 4). Compared to the middle period (1963-75), this period tended to have higher October-November water levels, much smaller high to low ranges (especially in years of nesting

failure) and lacked any correlation between the pace of early drying and timing of colony formation.

The lack of a correlation between early dry season drying and timing of colony formation during the third period is not understood. However, compared to the 1963-75 period, water levels at P-33 between 1976 and 1987 averaged 0.33 feet higher in November and 0.80 feet higher at the end of the dry season. The generally higher Shark Slough water levels, and lower high to low annual ranges, characteristic of this third period may have been at least partially responsible for negating the impact of rapid early-dry-season drying when it occurred. For this to be true, we assume that water levels must drop to some level before storks can begin to use the Shark Slough system to supply most of their food requirements.

Actually, the correlation between P-33 water levels and Wood Stork nesting events is not well understood since P-33 is not located near important stork foraging sites. The assumption has been that hydrological events at P-33 reflect wider patterns, although corresponding water data from important wading bird foraging sites in ENP are generally lacking. The data from the period 1953 to 1962, however, represent the closest we can measure of hydrological-wading bird relationships in a "naturally-functioning" southern Everglades. Simply stated, storks during this period usually had numerous options for feeding locations along the natural, shallowly-flooded borders of a much larger and more productive Everglades system, regardless of actual water levels or drying rates in the central Shark Slough.

Distribution of water deliveries since the early 1960's affected wading birds in two main ways. First, concentration of all southward water flow in the Everglades into the northern portion of ENP resulted in longer hydroperiod in the wetlands that received the flow, and in long-delayed and incomplete dry-season drawdowns. Often, food was never sufficiently concentrated and available to support major wading bird nesting attempts. Or, as was commonly the case with Wood Storks, food became available only late in the dry season, and nesting was delayed so that it could not be completed before the beginning of the summer rains. Second, the already reduced foraging area available to wading birds was sharply diminished by eliminating flow to northeast Shark Slough. This probably resulted in a substantial decline in aquatic productivity and loss of a significant portion of the available early dry season feeding habitat. Loss of these early season foraging areas meant that storks must shift their feeding to the more deeply flooded central Shark River Slough. Thus, it abruptly became the drier years, when water was low enough in the central Slough to support early winter foraging by waders, that became the successful nesting years. Because of additional reductions of productive foraging area, however, nesting attempts have also become

increasingly subject to disruption by dry-season rainfall events that interrupt the seasonal drawdown.

IV. Future Conditions

Wading birds

The number and success of nesting wading birds, in general, will correlate directly with the quantity, quality, and water level patterns in wetlands in the entire southern Everglades region. Any action that increases the area and improves the quality of wetlands and restores annual flooding/drying patterns, will benefit the population of waders that breeds in the southern Everglades. Conversely, any further deterioration of wetlands south of the Tamiami Trail will assure further losses in southern Florida breeding populations of waders.

Because tight correlations between specific wading bird activities and water management practices are not available, the strongest benefit for wading birds in the park from the proposed structural changes in the delivery system will be the greater flexibility in water management options for both the park and the Northeast Shark Slough (NESS). Further field studies are required to develop a predictive model for wader nesting-water management relationships. Pending the results of these studies, only broad recommendations of water management practices needed to recover wader populations in ENP can be made. The key to long-term success, however, will be to have a delivery system with enough flexibility to accommodate recommended modifications for wading birds and other biota.

It is certain that lengthened annual hydroperiods and substantially increased areas of flooding, especially in marshes peripheral to the central Shark Slough and east of the ENP boundary, along with a pattern of high, summer water level and adequate winter drying rates throughout these marshes, are the hydrologic events most likely to improve overall feeding conditions for waders in the park. Given these improvements, stabilization of the presently deteriorating Wood Stork population and return of the smaller waders to nesting in the traditional southern Shark River Slough colony sites is distinctly possible.

There is no doubt that if substantial numbers of wading birds are ever again to nest in mainland ENP, larger areas of viable wetlands that exist within the park boundary must be reestablished and maintained. The park probably will never again support the numbers of storks and other waders that nested there in the 1930's-1940's or even that nested there in the early 1960's. However, we believe that populations of storks and the smaller waders comparable in size to those of the early and mid-1970's (750-1,000 pairs for Wood Storks) can be reestablished given greater revitalization of a large area of southern

Everglades marshes and a better understanding of relationships between water delivery and impacts on bird feeding habitats.

The revitalization of NESS and the higher glades east of the park boundary will be an essential prerequisite to any significant improvement in wading bird populations in ENP. The sharply accelerated rate of decline by wading birds in the park began during the 1960's, when the eastern Everglades was severed from the remainder of the Everglades ecosystem. Although survey data on wader feeding patterns prior to the 1960's are nonexistent, it is highly likely that NESS and adjacent higher glades were of considerable seasonal importance to feeding waders. Wood Storks, to have formed colonies as early as November and December, must have fed in the shallow peripheral wetlands in and near ENP. During early winter, the central Shark Slough is normally too deeply flooded for effective foraging by even the largest waders.

In the absence of modifications to the present water delivery system, it is almost certain that breeding populations of Wood Storks and other waders in ENP will continue to decline. Populations of storks, White Ibis, Snowy Egrets, and Great Egrets have dropped at a dramatic pace since the 1970's. There is no sign that this trend will reverse itself without some significant change in water management practices. The Wood Stork, especially, may disappear as a breeding bird in ENP within the next 5 to 20 years if current water management practices continue. Other species may eventually stabilize at population levels capable of being supported by mangrove-estuarine habitats alone.

Fish

If trends in water deliveries to Everglades National Park that existed in the 1970's and 1980's were to continue, it is likely that fish populations would continue to be impacted adversely by unseasonable water releases, regular and extensive dry-downs, and unnatural hydroperiod alterations. Severe drought, exacerbated by water supply demands, have dried much of the central Shark River Slough marshes several times in the past decade. This has seriously reduced some fish populations (Loftus and Kushlan 1987), especially sunfishes, which are important prey for Wood Storks. Several years of reflooding of these central marshes are needed before the fish community can be restored to its pre-drought condition (Loftus and Chapman, unpubl. data). Prolonged flooding of marshes, as in Water Conservation Area 3A, results in fish community changes (Kushlan 1976a; Loftus, unpubl. data). The absence of seasonal fluctuations sharply decreases fish availability to wading birds. Shortening the hydroperiod of NESS marshes appears to alter marsh food webs, reduce aquatic animal biomass (Loftus et al., in press), and produce inferior foraging habitat for wading birds. Unseasonal water releases into Everglades National Park in the 1970's and 1980's dispersed

concentrations of fishes (Loftus, unpubl. data), probably leading to the disruption of nesting by wading birds.

The implementation of the proposed structural modifications in the water-delivery system should alleviate many of the past problems of fishes by providing a flexible water delivery system sensitive to ambient environmental conditions. By restoring flow to NESS, degraded areas of marsh should have increased hydroperiods with an ensuing increase in aquatic animal biomass. Because aquatic animal abundance appears to be correlated with highly organic soils in the Everglades (Loftus et al., in press), the increase in animal biomass in NESS may depend upon the renewed deposition of peats in that area. The degradation of NESS marshes has occurred over the past 25 years; it may take a similar period of increased hydroperiod to restore those marshes.

By increasing water input to NESS and Taylor Slough, marshes along the edges of those sloughs will have increased hydroperiods leading to increased animal biomass. This change should provide the wading birds that feed and nest in ENP with better foraging conditions over a longer time period than presently exists. Longer flooding may also make the peripheral marshes less susceptible to colonization by exotic fishes.

To preserve and increase fish populations and make them available to predators, it will be necessary to increase the hydroperiods of peripheral marshes and the marshes of NESS to maintain fluctuating water conditions in the Shark Slough basin and to provide residual pools in central Shark Slough as refuges and sources of fish to recolonize reflooded marshes in the wet season.

V. Monitoring

Wading birds

The biological impacts of any current and future water management practice, especially when substantial changes in water delivery are made, must be thoroughly monitored in and adjacent to ENP. Wading bird populations should be measured by a combination of regular aerial monitoring, and by ground-truthing of nesting colonies. The information collected should include colony location, timing of nesting, species composition, and nesting success for each site. All active colonies should be located and measured for at least a 3- to 5-year period following each major water management change. The location, timing, size, and success of colonies in ENP will accurately reflect the food resources and food availability in the wetlands south of the Tamiami Trail and in lower Water Conservation Area 3. The colony data can best be collected through an aerial survey program that includes monthly flights during the dry season (November-May) and enough ground visits to colonies to determine numbers and nesting success for species not easily seen from the air. A more modest but less desirable monitoring program would be one that only

measures Wood Stork numbers, distribution, and nesting success in ENP. A storks-only monitoring program would be justified only if everyone is comfortable with the assumption that any environmental improvement that substantially increases the number and frequency of successful nesting events by storks in ENP will also improve feeding and nesting conditions for all other waders.

The current program of systematic aerial counts of feeding waders should be continued. Longer hydroperiods in the eastern Everglades, in Taylor Slough, and in higher glades throughout ENP should result in significant shifts in distributions of feeding waders compared to recent patterns. Although these feeding flocks include many non-breeding and wintering birds, they are a potential source of new colonists; their feeding patterns should reflect locations of highest food concentration and availability for the entire population. Further, these data are essential for an understanding of colony locations and species content.

Fish

Because it is expected that reflooding NESS, Taylor Slough, and peripheral marshes will increase fish and invertebrate populations, periodic sampling of those marshes during and following the implementation of the structural modifications will confirm those population increases and allow calibration of water deliveries. Sampling of those areas during the dry season will also provide data on prey availability for foraging wading birds.

Information on fish populations at the marsh/mangrove interface in Everglades National Park, and the effects of water management on those populations, is lacking. Future studies must focus on those areas of ENP.

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Table 1. Wood Stork nesting in Everglades National Park, 1940's through 1980's. Nesting is considered successful when the number of young fledged was ≥ one per nesting pair.

Decade	Years of Successful Nesting	Mean Annual Breeding Population (pairs of adults)
1930's	7 of 9 years of record[1]	2,000-4,000
1940's	6 of 7 years of record	?
1950's	5 of 10 years	2,370
1960's	4 (1960, 1961, 1963, 1967)	1,930
1970's	2 (1974, 1975)	875
1980's to date	3 (1981, 1985, 1987)	375

[1] Based on recent review of Audubon warden reports, subject to revision (data on file, National Audubon Society, Tavernier, FL.).

Table 2. Generalized chronology of the effects of water control measures upon wading bird habitat in the southern Everglades, and associated status of breeding populations of wading birds.

Period	Habitat Effects of Water Control	Wading Bird Population Status
c. 1910 thru 1930's	Slow loss of peripheral wetlands; drainage probably creates earlier, more extensive seasonal drawdowns.	From a low caused by plume-hunding, populations recover to peak levels in 1930's.
1940's & 1950's	Loss of peripheral wetlands accelerates; over-drainage contributes to frequent dry-season drought/fire episodes throughout	Slow decline of most species, estimated at 20% for Wood Stork; nesting fails in many dry years.
1960's	Early years similar to 1950's; by end of period, initial works of CSFFC Project (L-29 & S-12, L-67, and 67E) completed and minimum delivery schedule to Park implemented.	Accelerating population declines and poor rates of nesting success; reverse of earlier pattern, with storks more successful during 1960's in drier years.
1970's &	Higher water levels and longer hydroperiods in Park with some flood releases in dry season; much lower water levels in WCA 3B and especially in NESS; loss of peripheral wetlands reaches c. 40%.	Precipitous decline of all nesting species; Wood Storks nest successfully in only 5 of 18 years and breeding population reaches about 1/10 of estimated 1930's level; no nesting in headwaters after early 1970's with some movement north into WCA 3A.

Table 3. Comparison between P-33 water levels (Everglades National Park) and the success of Wood Stork nesting, 1953-1987. P-33 data are the monthly maxima for the period in feet above sea level (ground elevation 5.11 feet).

	Mean Oct-Nov high (range)	Mean late dry season (range)	Mean high to low range
1953-1962(N)			
succ. nesting(7)	7.02 (6.65-7.67)	5.94 (5.43-6.69)	1.08 feet
fail. nesting(3)	5.95 (5.81-6.28)	4.75 (4.03-5.36)	1.20 feet
1963-1975(N)			
succ. nesting(4)	6.52 (6.17-7.10)	4.75 (4.06-5.36)	1.77 feet
fail. nesting(9)	6.54 (6.00-7.67)	5.45 (4.20-6.79)	1.09 feet
1976-1987(N)			
succ. nesting(3)	6.81 (6.47-7.01)	5.81 (5.65-5.92)	1.00 feet
fail. nesting(9)	6.82 (6.24-7.59)	6.13 (5.57-6.81)	0.69 feet

Table 4. Comparison between early-dry-season (November-January) drying at P-33 and the timing of colony formations by Wood Storks in Everglades National Park (expressed as the mean difference between highest November and highest January water level at P-33). P-33 ground elevation is 5.11 feet.

Period of colony formation	1953-1962(N)	1963-1975(N)	1976-1987(N)
November-December	0.29 feet (8)	0.52 feet (6)	0.36 feet (2)
January	0.37 feet (1)	0.32 feet (4)	0.10 feet (2)
February-March	--	0.16 feet (3)	0.30 feet (8)
No formation	0.32 feet (1)	--	--

ALLIGATOR POPULATIONS

George H. Dalrymple

Overview

The activities of the American alligator in the everglades make it a "keystone" species. Without alligators there are fewer ponds to serve as dry season refugia for fishes and aquatic invertebrates and, therefore, less prey for the populations of woodstorks and other wading birds (Craighead, 1968; Kushlan, 1974; Odgen, 1976). At the current time the alligator population has recovered from an estimated eighty to ninety percent reduction in numbers since the late 1800's (Craighead, 1968; Hines, 1979). However, the current population is recovering into very changed conditions in the Shark River Slough: the area that used to receive more water, the North East Shark River Slough, now receives less, and the area where the alligators are concentrated, the western Shark River Slough (inside the park) receives more water than it did prior to the legislated minimum deliveries schedule (before 1971). Moreover, in the western and central portions of the slough, especially south of the L-67 Extension Canal, the problem of water delivery has been compounded by the discharge of too much water, often too quickly, during the nesting season of the alligators.

A natural source of mortality in alligator populations is egg mortality caused by flooding; however, the egg loss can become excessive due to large and or rapid water discharges associated with water management (Kushlan and Kushlan, 1979; Kushlan and Jacobsen, 1984; Ogden, 1976). Alligators are so successful and have recovered from previous low numbers so rapidly that they can withstand higher egg mortality for many years before the population would decrease to the point that we would notice the changes in the everglades ecosystem. There would be fewer "gator holes" and reduced fish and bird habitat and there would be a "lag time" (e.g. 3 to 10 years) before we would know if the population was recovering. Benefits to Everglades National Park from an improved pattern of water deliveries are to a high degree dependent upon the activities of the alligators. Therefore proposed revision to the pattern of water delivery to the region must prove to be beneficial for the alligators.

Historical Background

Alligator populations in the region now included in Everglades National Park are estimated to have been extremely high before european settlement. Craighead (1968) estimated the population south of the Tamiami Trail to have been as high as one million animals, based on his evaluation of the number of "gator holes" present in the region. Throughout the period from the 1930's (Beard, 1938) to the mid 1960's the population was

described as declining and some researchers presented quantitative information to support both long-term and short-term reductions.

Stokes (1966) counted more than 300 alligators in a 1-mile section of Rookery Branch of the Shark River in 1958, and in 1966 he found only 3 alligators in the same area. Craighead (1968) reported more than 50 alligators in the Whitewater Bay tributaries in 1960, but found none in 1965. Hunting, poaching, hurricanes (e.g., Hurricane Donna in 1960) and human alteration and manipulation of the water levels in the area of Everglades National Park were contributing factors in Craighead's (1968) estimation that the alligator population in the park was reduced to 10 to 20 percent of the pre-settlement figure of one million by the mid 1960's (also see Hines, 1979).

The general belief in the rapid decline in numbers of alligators in the park was so prevalent in the early 1960's, when no water was being discharged into the park from the north, that intensive efforts were made to reduce poaching, and the extreme decision to dynamite artificial "gator holes" through the limestone to reach the water table was actually undertaken in the Taylor and Shark River Sloughs (Stokes, 1966; Toops, 1979; Jacobsen and Kushlan, 1984). With the return of surface water discharge and the listing of the species on the U.S. endangered species list in 1973 the population of alligators in the region began to increase again.

Present Status

The most recent extensive studies of alligator populations in the Everglades National Park indicate that the major problem facing the alligators in the park since scheduled deliveries of water began in 1971 has been excessive nest flooding (Ogden, 1976; Kushland and Kushlan, 1979). The statistical analyses of Kushlan and Jacobsen (1984) show that in the period before the first full year of scheduled deliveries started in 1971, there was a very significant correlation between early summer (June) water levels and later maximum water levels in the Shark River Slough, after 1971 there is no correlation. They also show that there is a significant positive correlation between early summer water levels (in the last 2 weeks of June) and the average height of alligator nests (also see Ogden, 1976 and Kushlan and Kushlan, 1979). They conclude that alligators in Shark River Slough used to be able to build nests in relation to early summer water levels that were correlated with maximum water levels and therefore egg mortality due to late summer increases in water level were minimized. Since 1971 there has been no correlation between early summer levels and late summer levels, and hence there is a greater liklihood of egg mortality from nest flooding. Kushlan and Jacobsen (1984), as well as all earlier researchers (Ogden, 1976), note that the alligator can respond remarkably quickly to improved conditions. They stress, that while some flooding is natural and can be absorbed by the population, that

the water deliveries to the park during the last decade have the potential to remove most of the small size classes from the population for enough years to lead to serious reductions in future breeding stock.

In low water years fewer alligators nest, and they nest at lower elevations (Kushlan and Jacobsen, 1984; Fleming, 1987). A higher percentage of the nests may flood in such years, but since the reproductive efforts is lower, the absolute loss is not as great. Emphasis may be placed on possible increased percentages of flooding in such years because late nesting season water levels may rise due to storms and, or flood releases by water management (Fleming, 1987), but it should be remembered that absolute nesting effort is lower in such years. Years with higher early wet season water levels may have ten times more nests (Fleming, 1987), a lower percentage flooding mortality, but a higher absolute mortality. Nest Flooding due to untimely discharges of flood waters by water management are avoidable and should be prohibited or at least mitigated, but some nest flooding will occur naturally, and the population is well adapted to survive it (Ogden, 1976; Kushlan and Kushlan, 1979). The more fundamental point is that more alligators nest when water conditions are higher in the early wet season, and so we should be particularly mindful of water deliveries that may increase percentage nest flooding in such years. Moreover, a trend for increased alligator productivity will require more years with higher early wet season water levels, less management induced nest flooding during the incubation period, and more suitable habitat for alligators to live in.

Over the three year period 1985 through 1987, alligator nesting density averaged 6.5 times greater in Everglades National Park than in the North East Shark River Slough (0.26 per km^2 in the Shark Slough within Everglades National Park and 0.04 nests per km^2 in the North East Shark River Slough, Fleming, 1987). The average density of "open water ponds with alligator trails" was 40 times greater in the park than in North East Shark River Slough (0.80 ponds per km^2, +/- 0.10, in the Everglades National Park versus 0.02 per km^2, +/- 0.02, in the North East Shark River Slough, Fleming, 1987). At the present time the alligator is almost completely restricted to the portion of the slough within Everglades National Park.

Future - with the plan

The current problem for the alligator population is very clearly tied to the pattern of water discharges into the Shark River Slough. Ideal conditions for alligators appear to fall within the range of natural conditions expected for the everglades during any given series of years: 1) moderate, progressive reduction in surface water during the dry season, culminating in lowest levels in late May coincides with increasing densities of adults in anticipation of mating, 2) positive correlation between early wet season (late June) surface

water levels and later maximum water levels (late August) results in nests being built at heights that minimize nest flooding and egg mortality.

For the alligator in the everglades, the benefits of the proposed structural modifications to the levees and canals will permit the flexibility necessary to more effectively control dry-down (minimizing reversals or dry season flooding) and permit correlation of early summer and maximum surface water levels. A revised program of water delivery into the entire Shark River Slough including the North East Shark River Slough will permit alligator range expansion that would prove beneficial to all of the diverse species, from plant communities, fishes, wading birds, turtles, and invertebrates (such as crayfish and snails), that are so closely linked to the ecology of the alligator (Craighead, 1968; Fogarty, 1974; Ogden, 1976; Kushland and Kushlan, 1980).

Future - without the plan

Without the revisions in the plan of water deliveries, the alligator population will be restricted in range to the western portion of Shark River Slough and restricted in available habitat, and the quality of this habitat will be low due to the potential for rapid and or large water discharge into the park. Alligator numbers will expand more slowly and there is a higher potential for density dependent factors to affect reproductive rate within the restricted range. Refuges for aquatic life and sources of food for wading birds will suffer along with the alligators.

Of all of the species in the everglades, none is considered to be more central to the ecological well-being of the ecosystem than the alligator. Because the alligator is long-lived, responds quickly to improved conditions, and is able to absorb the normal range of natural drought and flooding in its population dynamics, it should serve as an important priority in restoring more natural conditions to the Everglades National Park.

Monitoring

1. Aerial surveys of the number of alligator nests and "gator holes" in the Everglades National Park, the North East Shark River Slough and the Taylor Slough basin are the most effective method for evaluating regionwide status of the alligator. Nest surveys need only be done during the peak period of nesting, June 15 - July 15. "Gator holes" should be surveyed at least once during each dry season.

2. Survey subsets of nests each year to evaluate actual nest flooding potential in different regions.

3. Monitor water levels during nesting each year in order to establish a preferred water level later in the nesting season, to control the extent of egg mortality.

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AN ASSESSMENT OF THE POTENTIAL BENEFITS TO THE VEGETATION AND WATER RESOURCES OF EVERGLADES NATIONAL PARK AND THE SOUTHERN EVERGLADES ECOSYSTEM ASSOCIATED WITH THE GENERAL DESIGN MEMORANDUM TO IMPROVE WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Statement Paper
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May, 1987

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INTRODUCTION

The Everglades ecosystem was at one time a vast freshwater wetland complex, and now supports a variety of land uses, ranging from intensively managed agricultural areas in the north to water conservation areas in the middle regions. Everglades National Park is at the southern terminus of the original Everglades ecosystem and was established in 1934 for the preservation of the natural and scenic values contained therein. The Park is bordered on the north by Water Conservation Area 3A (WCA 3A), to the northeast by Water Conservation Area 3B (WCA 3B), and to the east by Northeast Shark River Slough (NESRS) and other privately owned lands primarily in agricultural or residential land uses. These different land uses and their associated water needs have led to an alteration in the natural hydrologic regime within the once contiguous southern Everglades ecosystem.

Water is a crucially fundamental part of the ecosystem, important not only because of direct effects on the biota of the wetlands, but also because of its' influence on ecosystem processes. Inundation patterns, along with other factors, determine the distribution and composition of the vegetation communities within the system. The periphyton, or algal communities, within the marshes are also related to, not only the physical hydrologic regime, but also the chemical constituents within the water and substrates. Ecosystem processes, such as the primary production, nutrient cycling and fire regime are all related to and a function of various aspects of the hydrologic regime.

In this report, we discuss the potential benefits of hydrologic restoration to the vegetation and water-related components of the southern Everglades ecosystem. The modifications necessary to initiate restoration of the hydrology within this area are explained within the General Design Memorandum (GDM) for Improved Water Delivery to Everglades National Park. We discuss the potential impacts of these improved hydrologic conditions on resources and processes both within the Park and outside of the Park. External resources and processes are included because of their importance to the preservation of the resources within the Park.

We have divided the report into six topics; each is either an important component of the ecosystem, an important process, or a particular threat to the preservation of the values of Everglades Park. The topics include Water Quality, Water Quality Effects on the Vegetation, Periphyton, Vegetation Communities, Fire, and Exotic Plants. Within each topic we discuss the historical, present, and future conditions, and include monitoring recommendations. The status of these resources as they existed in 1934, the time of creation of Everglades National Park, is recounted in the historical conditions. Changes and degradation of the resources are reported in the present conditions section. The

future and status of the resources are projected, both with the GDM plan and without the GDM plan. Finally, recommendations are made to monitor each resource following initiation of the plan.

The authors listed on the title page are listed alphabetically, authorship of each topic is as follows: Steven Davis-Nutrient Impacts on Vegetation and Periphyton, Lance Gunderson-Vegetation Communities and Introduction, Ronald Hofstetter-Fire and Exotic Plants, David Swift-Periphyton, and Bradley Waller-Water Quality. All authors in this report participated in the preparation of all secitons, including discussions and comments. We acknowledge and appreciate the comments of other attendees at the meeting from which this document was prepared.

BASELINE WATER QUALITY

Historical Conditions

Prior to 1934, water quality conditions in the southern Everglades were not affected by upstream alteration. The Miami Canal, which is the closest major canal draining the Everglades Agricultural Area (EAA), was dredged to a point slightly north of its connection with the south New River Canal (Parker et al. 1955) and thus did not transport significant amounts of water from upgradient, developed area. The two primary sources of water in the southern Everglades were overland flow from the upland Everglades and Big Cypress marshes, and by direct rainfall.

Historic water-quality characteristics can be inferred from present day analogs of stations unaffected by water management practices and anthropo-genic effects. The dominant inorganic ions were calcium and bicarbonate, which were typically higher in concentration in water covering marl soils rather than peat or organic soils. Marsh water was typically nutrient deficient with inorganic phosphate being the limiting nutrient, probably in concentrations less than 0.004 mg/l. Inorganic nitrogen concentrations were dominated by nitrate, generally in concentrations less than 0.10 mg/l. Present day analogs of characteristically pristine marsh conditions can be found in analuses of water from the marsh north of S-12A in conservation area 3A, marsh waters in conservation area 3B, and at Everglades station P-34 (Waller and Earle, 1975; Waller, 1982; Flora and Rosendahl, 1982; Swift and Nicholas, 1987).

Major water management changes occurred in the southern Everglades basin in the period 1950 to 1970 which directly affected the hydrologic regime in the southern Everglades (Leach et al. 1972). Major structural changes which directly affected water quality characteristics in the southern Everglades included pumping stations S-8 and S-9, construction of Levee 67A borrow canal and its subsequent connection to the Miami Canal, construction and operation of the S-10, S-11, and S-12

structures, and the construction or L-67 extension borrow canal to facilitate flow within Everglades National Park. With these changes, more water could be channeled directly from developed area, including the EAA, to discharge points within ENP. Because the water is channelized, a higher rate of flow to the south is achieved without the benefit of sheet flow through the marsh which would facilitate nutrient uptake.

Present Conditions

Since 1960, water quality changes have been noted in the southern Everglades marshes and canals (Klein et al. 1975). These changes have been directly attributable to the diversion of water down the L-67A canal from the northern Everglades (Waller, 1982). Most notable of these changes have been increasing concentrations of sodium, chloride, magnesium, color, and iron in the Shark River Slough in ENP, along the Tamiami Canal between Levee 30 and 40-Mile Bend, and in the southeastern part of conservation area 3A (Waller, 1982; Waller and Earle, 1975; Lutz, 1977) and changes in conductance (Flora and Rosendahl, 1982). Sources of the observed increasing constituent concentrations include connate seawater in the northern Everglades, breakdown of organic soils, peat fires, and fertilizers. Also noted in the previously cited studies were increased concentrations of nutrients, primarily nitrogen and phosphorous, in the canal waters in the northern Everglades basin and high pesticide and heavy metal (micronutrient) concentrations in canal bottom materials. Sources of the nutrients include oxidation of the drained, organic soils, sediment runoff, and fertilizers. Heavy metals are derived from both pesticides and micronutrients, and pesticide residues are primarily form agricultural activities in the EAA.

At present, poor quality water from the northern Everglades is reaching the inflow points to ENP (Mattrow et al. 1987). Inorganic nitrogen and phosphorous concentrations which are higher than background or pristine conditions have been measured in the L-67A borrow canal and at the S-12 discharge points to ENP. No increases have been noted however, in the concentrations of inorganic ions, color, or iron.

Future Conditions

Without the Plan.

Without any structural changes in the present water-management system, the water-quality effects from the agricultural and urban areas in the northern Everglades basin should continue. Major ion, color, and iron concentrations should continue to increase until they reach equilibrium primarily by the physical processes of dispersionand dilution from rainfall and overland sheet flow. If inflow from the EAA is kept at the present level or greater, increases in nitrogen and phosphorous concentrations at the northern points of inflow to ENP should increase. Also,

dependent on the volume and rate of flow from the pumping stations, sediments and bottom material contaminated with metals and pesticides should migrate slowly southward through the conservation area canals.

With the Plan.

With the structual changes proposed in the GDM, a general improvement in water quality at the entrance points to Everglades National Park is expected. Most notable will be a decrease in the nutrient concentrations in the lower sections of L-67A canal and a decrease in contaminated sediment transport in the L-67A canal due to a decrease in the rate of flow. By diverting the flow through the marsh, uptake of inorganic nutrients will occur and flow velocities will decrease, thus enabling suspended sediments to settle. Sodium, chloride, magnesium, color, and iron concentrations may decrease in waters flowing directly into ENP because of the diversion of water to Conservation Area 3B, thus providing a greater potential for dilution by sheet flow and rainfall.

Monitoring Recommendations

An expansion of the existing water-quality monitoring program will be necessary to document any changes that may occur as a result of the implementation fo the GDM. Stations should be selected to best identify sources of degraded water within and adjacent to the conservation areas, to gauge the effect of new structural controls on baseline water quality, and to characterize the quality of water at entry points to Everglades National Park and northeast Shark River Slough. Some of these stations are long-term data collection sites and currently in existence and some will have to be established or re-established. Both water column and bottom materials should be sampled to best characterize existing or potential water-quality problems, identify sources, sinks, and transport fo contaminants as well as temporal change of these parameters. Frequency of sampling should be tied to hydrologic conditions such as extreme dry season, first flush of the wet season, high water levels, receding water levels, and periods of agricultural backpumping and irrigation. Chemical constituents and physical property measurements should be selected to best characterize the water and bottom material conditions. Those parameters selected will be used to trace the source of degraded or contaminated water. Field measurements should be made of the following parameters: major ions, nutrients, metals applied in agricultural activities, and selected synthetic organic constituents such as insecticides, nematocides, fungicides, and herbicides. Parameters analyzed should reflect both historic (previous) conditions and current contaminant sources.

NUTRIENT IMPACTS ON VEGETATION

Historical Conditions

Direct rainfall apparently provided most of the water and nutrient supplies to the historical Everglades (Davis, 1943; Parker, 1974). As a result, phosphorus (P) and nitrogen (N) are thought to have been in short supply and on tight sysles (Steward and Ornes, 1975). This apparently was the situation in Everglades National Park (ENP) at the time of its establishment in 1934. The low nutrient status of the historic Everglades is reflected in the predominant macrophyte and periphyton communities in areas where nutrient supply has remained low. Sawgrass was, and still is, a major component of Everglades vegetation (Davis, 1943; Loveless, 1959), and the dominance of this sedge has been attributed in part to its low phosphorus requirements (Steward and Ornes, 1975). Periphyton communities in pristine areas of low nutrient supply are characterized by high species richness (Swift and Nicholas, 1987) which tends to maximize utilization of limited nutrient supplies. The Everglades is thus viewed as an ecosystem which evolved under very limited supplies of nutrients where even minor increases in nutrient supply have been observed to have major ecosystem impacts.

Present Conditions

Nutrient supply to the Everglades has increased since 1934 primarily as a result of drainage of Everglades Agricultural Area (EAA) runoff into the water conservation areas and ultimately into ENP. Water containing elevated concentrations of P, N, and cations presently enters the park via L-67A through the S-12 structures and S-333. Nutrient impacts on ENP vegetation and periphyton communities have been relatively minor up to present due to uptake by water conservation area marshes upstream of the park. However, water conservation area sawgrass and cattail communities appear to have a limited uptake capacity for P and N (Davis, 1986b). Once this capacity is reached, nutrients are recycled rather than stored and are ultimately passed downstream. Observed environmental impacts accompanying increased nutrient supply include a progressive macrophyte community shift from sawgrass to cattail (Davis, 1986a), a periphyton community shift toward lower abundance of diatoms and desmids (Swift and Nicholas, 1987), and reduced dissolved oxygen concentrations in surface water (Belanger and Platko, 1986; Swift, 1987). These impacts became measurable when mean annual orthophosphate concentrations rise to levels of 0.020--.030 mg/l in surface water (Davis, 1986a, b; Swift and Nicholas 1987). Inflow concentrations of orthophosphate to ENP via L-67A have varied during the last decade, with annual means ranging from 0.004 to 0.013 mg/l. Mean annual nitrate concentrations entering ENP have reached a 0.16 mg/l, with a 4-year mean (1978-1982) of 0.10 mg/l at S-12D (Mattrow et al. 1987). Flora et al. (1987) found slow

changes to occur in the native periphyton communities and a minor inhibition of macrophytic growth in a marsh which was dosed at lower nitrate concentrations than this annual mean. Cattail expansion has been observed (Gunderson, pers. comm.) to the west of L-67 Extension Canal in ENP, and is attributed to increased nutrient concentrations.

Future

Without the Plan.

With mean annual orthophosphate concentrations in L-67A approaching 0.020 mg/l, adverse water quality impacts on ENP appear to be forthcoming during the next decade. The progressive change in vegetation and periphyton communities and alteration of the dissolved oxygen regime which have been described for the Water Conservation Areas may become evident downstream of S-12C and D and west of L-67 Extension by the turn of the century.

With the Plan.

Routing of L-67A discharges through WCA-3B and the northeast Shark River Slough should delay adverse water quality impacts on ENP until a regional plan can be developed to reduce southward flowage of EAA runoff. Overland flow across the marshes of WCA-3B and northeast Shark River Slough is expected to reduce orthophosphate concentrations in ENP inflows to below 0.020 mg/l, and measurable water quality impacts on the Park will be avoided by this plan. However, this solution should be viewed as temporary, in that it may offset water quality problems for ENP for a few decades. Without control of EAA nutrient inputs into the Water Conservation Areas, uptake capacity of WCA-3B and northeast Shark River Slough marshes will eventually become saturated and nutrient inputs to ENP will again pose a problem. Perpetuation of the remaining Everglades ecosystem depends on relieving the Water Conservation Areas and ENP from downstream impacts of EAA runoff. This GDM and other plans to protect ENP are related to, and strongly dependent upon, regional plans for the amangement of the Everglades ecosystem as a whole.

Monitoring Recommendations

1) Establish four transects for monitoring nutrient penetration and biological responses in marshes of WCA-3B, northeast Shark River Slough, and Everglades National Park.

   a) Transect in WCA-3B extending from the middle of L-67 south to L-29 with marsh sampling locations at 1-mile intervals.

   b) Transect in northeast Shark River Slough extending south from L-29 with marsh sampling locations at 1-mile intervals.

c) Transect in ENP beginning south of L-67 Estension, and extending southwest into Shark River Slough, with five marsh sampling locations at 1-mile intervals.

d) Transect in ENP extending south from S-12D with five marsh sampling locations at 1-mile intervals.

2) Monitor water quality and biological parameters at marsh sites according to the following schedule:

a) Monthly collection of water samples to be analyzed for TPO4, OPO4, TKN, NO3, NH4, Cl, Na, Mg, K, and Ca.

b) Quarterly collection of periphyton samples for analysis of tissue P and N concentrations.

c) Semi-annual collection of periphyton samples for identification of predominant species.

d) Semi-annual collection of sawgrass (and other dominant macrophyte) leaves for analysis of tissue P and N concentrations.

3) Continue remote sensing efforts for monitoring distribution of major vegetation communities in WCA-3B, northeast Shark River Slough, and Everglades National Park.

PERIPHYTON

Historical Conditions

Periphyton are a conspicuous and ecologically important element of the Everglades ecosystem. As primary producers, periphyton respresent a major component of the marsh food chain. Periphyton provide both food and habitat for a wide variety of grazing invertebrates and forage fish which are in turn consumed by wading birds, reptiles, and sportfish (Tabb et al. 1967; Carter et al. 1973). Laboratory studies have shown that periphyton may be an important food source for Everglades crayfish (Pope et al. 1981). The formation of thick periphyton mats aids the survival of aquatic organisms during drought by preventing the desiccation of their eggs and larvae (Harrington, 1959). As water levels rise, aquatic insects and forage fish rapidly repopulate the reflooded marsh. A large portion of the total primary production of the lower Everglades appears to be derived from periphyton algal mats (Wood and Maynard, 1974; Browder, 1981). It is estimated that nearly all of the diurnal variations in dissolved oxygen content within Everglades open water sloughs are due to periphyton photosynthesis and respiration (Hunt, 1961; Swift, 1987). Periphyton growth and metabolism directly influence marl deposition and soil building

processes in the marsh (Craighead, 1971; Gleason, 1972; Gleason and Spackman, 1974).

Information prior to 1930 suggests that seasonal inflows into ENP inundated a much wider area of the marsh over longer periods of time as compared to present day conditions (Parker, 1974). If these data are correct, periphyton mats covered a much wider aea of the lower Everglades on a seasonal basis than today. As primary producers, these algal communities may have supported larger standing stocks of forage organisms (i.e., grazing invertebrates and fish) for utilization by wading bird populations.

Everglades periphyton communities have probably developed historically within an essentially nutrient-limited ecosystem. The presence of low elemental phosphorus (P) concentrations within Everglades periphyton cell tissue and low availability of P in surface waters indicate that P is the growth limiting nutrient to periphyton in the interior Everglades marsh (Swift, 1981; Swift and Nicholas, 1987). Due to its low availability, inorganic nitrogen may also seasonally function as a co-limiting nutrient.

Present Conditions

Loss of historical inflows have reduced aquatic produtivity of ENP by reducing the areal coverages of the periphyton community. Reduced inflows also appear to have affected periphyton species composition. Browder et al. (1981) showed that the taxonomic compostition of ENP periphyton was significantly correlated with hydroperiod length and soil percent organic matter, which are both largely regulated by water management activities. Shortened hydroperiods and low percentages of soil organic matter favored the development of blue-green periphyton over other groups of algae (diatoms and green algae). Other studies showed that both fish and incertebrate grazers selected against blue-greens favoring diatoms or green algae as a preferred food source (Browder et al. 1980). It is unknown how these differences in food item selection presently impact marsh secondary production.

At present, nutrient impacts to ENP periphyton communities are not well documented but are assumed to be relatively minor (Flora et al. 1987). There is concern that nutrient loading to the park will continue to increase and, therefore, have the potential to impact ENP algal assemblages.

Nutrient-enrichment of marsh surface water has significantly impacted the structure and function of Everglades periphyton communities (Gleason, 1974; Swift, 1981; Swift and Nicholas, 1987) may have long-term impacts on marsh biota. Inasmuch as periphyton represent the base of the Everglades food web, major changes in the species composition and biomass of the primary producer community ultimately influence the species composition and biomass of higher trophic level organisms. Changes in food

item size, selection choice, or nutritive value as a result of nutrient-enrichment may presently limit the standing crop of grazing invertebrates or fish fauna.

Loss of, or major changes in, the species composition of the periphyton mat also directly influences the dissolved oxygen regime of the marsh (Belanger and Plakto, 1986; Swift, 1987). Nutrient-enrichment of the Everglades marsh eliminates native oxygen producing (autotrophic) algal mat communities and stimulates the production of a less efficient oxygen consuming (heterotrophic) flora (Swift, 1987). General reductions in the diurnal oxygen content of marsh surface waters restrict the numbers and types of aquatic organisms that can tolerate periodic oxygen minima.

Periphyton species composition and algal species diversity have been shown to be significantly influenced by the ionic content of marsh surface waters. Low ionic content waters support high algal species diversity while highly mineralized waters (calcium carbonate, chloride, and sodium) support a less diverse flora (Swift, 1981; Swift and Nicholas, 1987). Chloride (Cl), sodium (Na) and magnesium (Mg) concentrations have been shown to be increasing and to presently impact the northern ENP ecosystem (Mattraw et al. 1987). Continued long-term increases in Cl, Na, and Mg concentrations within the northern Shark River Slough region of the park (Waller, 1975; Flora and Rosendahl, 1982) could impact the park by reducing periphyton species diversity.

Future Conditions

Without the Plan.

Projected long-term increases in nutrients and major ion content will slowly change periphyton species composition and diversity, algal growth rates and the dissolved oxygen regime of the park's northern peripheral marsh. The areal extent of these changes and their impacts on higher trophic level organisms cannot be accurately assessed at this time. Further reductions in hydroperiod length combined with the present poor water distribution system will limit the areal coverage of the primary producer community (periphyton) thus reducing the overall aquatic productivity of the ecosystem.

With the Plan.

The plan will insure the protection of the park's sensitive algal mat communities, the base of the Everglades food web, by reversing the trend of increased nutrient loadings to ENP. The plan will also redistribute water over a much broader area of the park: lengthening hydroperiods, increasing the areal coverage of periphyton may communities, and thus increasing the overall productivity of the ecosystem.

Monitoring Recommendations

Suggestions for monitoring water quality and ENP periphyton communities have been incorporated into the section on "Nutrient Impacts on Vegetation".

VEGETATION COMMMUNITIES

Historical Conditions

The descriptions of the vegetation by Davis (1943) provide baseline information on the vegetation resources in 1934. The wetland communities of the southern Everglades included sawgrass marshes (both dense and sparse), sloughs (with aquatic plants), marsh (marl) prairies, tree islands with bay forests, and cypress forests. Upland communities included Miami rockland pine forests and hammock forests, both in the pinelands and as tree islands surrounded by wetland vegetation. The central portion of Shark River Slough was primarily slough vegeation, characterized by open water, spikerush (*Eleocharis* sp.), bladderworts (*Utricularia* spp.), and water lily (*Nymphaea* sp.). The sawgrass marshes were nearly monospecific stands of *Cladium jamaicense*. The swamp or bay forests were comprised of red bay, *Persea borbonia*, sweet bay, *Magnolia virginiana*, and dahoon holly, *Ilex cassine*.

Little is known of the historical ecosystem processes, such as primary productivity, mineral recycling, and organic soil formation within these communities. It can reasonably be inferred that significant primary production occurred as a result of periphyton and macrophyte photosynthesis within both the aquatic slough community and marl prairie community. Periphyton productivity only occurred when standing water was present. Peat accumulated as a result of biomass production in sloughs, sawgrass marshes, and tree islands (swamp forests) during periods of prolonged inundation and little exposure of sediments to oxidation during the dry season.

The relationship between plant communities and hydrologic regimes has been investigated by Davis (1943), Egler (1952), Craighead (1971), McPherson (1973), Pesnell and Brown (1977), Olmsted et al. (1980), Zaffke (1983), and Gunderson (1987). A gradient of water depths and associated hydroperiods (length of inundation) exists amoung these communities. The hammocks and pinelands are the driest communities. The marl prairies have intermediate amounts of flooding, averaging 6-8 months of depths up to 1 foot (Olmsted et al. 1980). The swamp forests and dense sawgrass stands have slightly longer hydroperiod and deeper water. The slough communities are the wettest sites, with almost continuous inundation. Quantification of hydroperiods within these communities is difficult due to high annyal variation. These communities are established in response to a number of

factors, including hydrologic regime, soil characteristics, fire and seed dispersal, and germination requirements. Once established, the communities appear tolerant of a considerable range of hydrologic conditions. However, changes can occur due to alteration of the hydrology, with direct effects due to prolonged flooding or droughts and indirect effects which are associated with an altered fire regime.

Present Conditions

Most of the communities described by Davis (1943) are still present. Changes have occurred in the species composition, structure, and spatial distribution of some communities (Alexander and Crook, 1974), which can be related to altered water conditions associated with management. Ecosystem processes have also probably been altered. The impact of exotic plant species and altered fire regimes are discussed in other sections. Unnatural alterations and resource degradation are listed below.

Sawgrass density and abundance has been altered due to prolonged flooding in some areas and fire impacts associated with shortened hydroperiods in other areas. Periods of prolonged flooding in the mid 1970's contributed to observed "decadence" or decrease in culm density and stature (Hofstetter and Parsons, 1975). A similar condition exists in souther Water Conservation Area (WCA) 3A (Tanner et al. 1987). Once these sites have dried, the open areas in the sawgrass stand have been colonized by hardwoods such as pond apple, Annona glabra. Sawgrass density has also decreased in northeast Shark River Slough (NESERS), due to shortened hydroperiods, peat oxidation, and increased fire frequency and severity.

The abundance of willow, Salix caroliniana, and cattails, Typha spp., has increased within the Park and in surrounding area. Severe, peat consuming fires associated with management-exaggerated droughts have resulted in an increase of willow (Craighead, 1971). Cattails have established in the marshes adjacent to L-67 extension canal as a result of the movement of nutrient rich waters via the canal into the marsh.

Woody species have expanded into gramineous wetlands in areas of reduced hydorperiod. This is occurring in northern Taylor Slough within the Park, with red bay, dahoon holly, way myrtle, Myrica cerifera, establishing in the marl prairies of this area (Olmsted et al. 1980). Some of the marl prairies within the pinelands (finger glades) of ENP have been colonized by south Florida slash pine, Pinus elliottii var. densa, (Olmsted et al. 1984) also as a result of shortened hydroperiod. Mangroves in the headwaters of Shark River, appear to have also established in the surrounding marshes (Kolipinski and Higer, 1969). Tree islands in the deeper central area of northeast Shark River Slough appear to have increased in size (Gunderson et al. 1986) also as a result of shortened hydroperiod in the surrounding marsh.

Tree islands (both swamp and hammock types) in the eastern edge of northeast Shark River Slough have suffered changes in size, structure, and composition (loope and Urban 1980) as a result of increased fire frequency and shortened hydroperiods. The stands are smaller, and are colonized by ferns and weedy species, as well as exotics.

The marl prairies in the East Everglades and northern Taylor Slough may have undergone subtle changes in species composition. Muhly grass, Muhlenbergia filipes, was not mentioned by early botanists and my have increasd in abundance in these areas (Olmsted et al. 1980, Atwater 1955). The increase is attributed to shortened hydroperiod and increased fire frequency and is associated with a decrease in the sawgrass density.

Hardwoods in the swamp forests are sensitive to prolonged flooding. In the southern end of WCA 3A (Zaffke 1983) and in WCA 2 (Worth 1987), tree islands have decreased both in size and stem density as a result of hardwood mortality. Craighead (1971) also observed hardwood martality as a result of unnatural flooding along L-67 Canal Extension in ENP during the late 1960's. Gunderson et al. (1986) found wax myrtle, dahoon holly and cocoplum, Chysobalanus icaco, to be sensitive species to these flooding events.

Total primary production in the marshes has probably been depressed in northern Taylor Slough (ENP) and other marl prairies due to shortened hydroperiods. Soil formation, both peats and marls, is linked to primary production and hydroperiod, with inundation necessary for both primary production and soil formation.

Future Conditions

Without the Plan

All of the trends mentioned in the present conditions secton should continue to occur unless changes are made. Prolonged flooding, created by management conditions will kill swamp hardwoods and decrease sawgrass density along L-67 canal and in southern WCA 3A.

Effects of shortened hydroperiods and lowered water depths will also continue. Establishment of woody species in gramnoid wetlands will continue. Muhly grass will continue to increase in abundance with a decrease in sawgrass density. Increasd fire frequency will continue to burn out tre islandsl and decrease sawgrass abundance. Primary production and formation of peat and marl soils will be depressed in these areas.

With the Plan

A decrease in management-exaggerated flood events within the park would reduce mortality of hardwoods in and around tree islands. Sawgrass decadence would be less common, occurring only in response to natural events.

Restoration of flow and hydroperiods to NESRS would increase density of sawgrass in marl praries and sawgrass marshes. Fire impacts should be reversed, with sucession towards more natural communities, not weedy, early successional communities.

Removal of the L-67 Extension Canal and Levee would halt the movement of nutrient-laden water into the marshes and subsequent invasion of cattails. Peak stages would be reduced during flood releases, thereby curtailing hardwood mortality.

Re-establishment of hydroperiods in northern Taylor Slough and the wetlands around Long Pine Key would stem the establishment of hardwoods, especially exotic species, and pines into the marl praries. Sawgrass abundance may increase in the praries.

Restoration of natural water distribution (spatially and temporally) into the marshes and praries of the southern Everglades in and around ENP would recrate the conditions necessary for optimum primary production, nutrient cycling, organic soil formation, and energy flow through these wetland vegetation communities.

Monitoring Recommendations

Establishment of long-term monitoring plots within all of the wetland communities would allow for monitoring and evaluation of changes in species abundance and composition. Qunatitative inventories of all species would provide data on subtle shifts in abundance, and relate changes to water-management. Plots established as boundaries between communites would track movement of these ecotonal areas. Previous work, such as the plots established by Alexander and Crooks (1974), should be used as baseline information from which long-term monitoring programs for ecosystem functions of productivity and nutrient cycling is also necessary to evaluate these aspects of the ecosystem.

FIRE

Historical Conditions

Fire has been an important natural factor associated with lightening primarily durin the wet season (Egler 1952; Craighead 1971; Hofstetter 1973, 1974; Wade et al. 1980). By 1934, the development of canals, levees, roads, farm fields, and other artificial fire breaks interrupted the run of natural wet-season fires, thus reducing natural fire frequency and consequently allowing succession to occur at the expense of the prevailing natural communities.

By 1934, however, the human population in southern Florida had become substantial and man's activities in the Everglades had risen significantly. Fires, by both accidential and deliberate ignitions, increased in frequency with man's increased presence. It was the increased frequency of fire by man's actions in the dry season, when fires are not naturally common, however, that added a severe stress on native species. These dry-season fires kill individuals of species that are otherwise naturally fire-dependent; consume the upper layer of organic sediments, alter the critical surfact topography, and release excess nutrients.

The dry-season fires, additionally, promoted the spreade, establishment, and eventual dominance of exotic species, notably Melaleuca, in may natural communities (Wade et al. 1980). The regionally lowered water table caused lengthening and intensified action of the dry season, permitting even more destruction by these fires.

Present Conditions

In the drier conditions of the last 4 decades, destructive fires, primarily of incendiary dry-season type, have destroyed or damage numerous tree islands, pinelands, and wetlands with organic soils in ENP (Hofstetter 1973, 1974; Hofstetter 1980; Taylor 1981). Many of these fires have entered the Park from the East Everglades where unusually dry conditions have permitted fires to spread rapidly and broadly. These fires, along with unfavorable hydrologic conditions, have weakened individuals of native species permitting the establishment of exotic species, particularly Schinus on tree islands and Melaleuca in marshes and islands.

Future Conditions

Without the Plan

With the increasing human density in southern Florida and its increasing demands on water and increasing activity in the wildlands of southern Florida, man-caused fires will become more frequent and the intensity and damage of these fires will increase. The results will be the direct destruction of plant communities particularly along certain boundaries by fire and the increasing establishment and dominance by exotic plants species.

The problem will be most severe during dry years, but willbe a constant threat. Prescribed burning will have to be used more to supplement natural fires and control spread of unfavorable conditions.

With the Plan

The rturn of more natural hydrologic conditions will reduce the probability of the occurrence of destructive peat (ground)

fires by reducing the time in the dry season when the moisture content of surface peats is at ignition conditions.

The return of more favorable hydrologic conditions will reduce the stress on native species and permit them to compete more favorably with exotic species. The healthier the native communities, the less the need to supplement natural conditions by management techniques, such as prescribed burning.

Monitoring Recommendations

The current procedures for reporting, recording (mapping) and responding to fires along the Park's boundaries seem quite acceptable. A knowledge of the location and status (size, density, reproductive state, etc.) of *Melaleuca* along the Park's boundaries is essential for the fire monitoring program. Clearly, dry-season fires play a major rold in the spreading and establishment of *Melaleuca* in southern Florida. Control measures should be undertaken where feasible to keep these fires out of *Melaleuca* stands near the Park borders. Areas with *Melaleuca* that have burned during the dry-season are likely to have extensive release of seeds and potentially high seedling establishment, and so, need to be monitored for at least a year after the fire.

EXOTIC PLANTS

Historical Conditions

Details on the distribution of exotic species in southern Florida in 1934 are not known. Exotic plantsl, which were present at Royal Palm Hammock State Park, were not readily invading adjacent natural communities. Exotic species did not exist in numerous areas in southern Florida, but were probably not a problem in the area that was to become Everglades National Park (ENP).

Present Conditions

Since the 1930's several exotic plant species have become a problem in parts of Everglades National Park and adjacent areas (Klukas 1969; Wade et al. 1980). Aquatic weeds are found but have not yet posed a major problem in ENP. Three woody exotic genera pose threats to the park: *Casuarina*, *Melaleuca*, and *Schinus*.

Water hyacinth, *Eichhornia crassipes*, ahs been found in L-67 Extension Canal, and was mechanically removed several times, only the reinvade the open water. This exotic has moved up to several hundred yards into adjacent marshes of the Park, but has failed to survive in the native areas.

Australian pine, *Casuarina* spp., has established in several areas in and around the Park, particularly Highland Beach and

southwest of the intersection of U.S. Highway #1 and C-111 (southeastern panhandle of the Park). Casuarina has also moved westward across the East Everglades to become established within a mile of the northeastern Park boundary. Cajeput, Melaleuca quinquenervia, has also rapdily spread across the northern part of the East Everglades and into Everglades National Park.

Brazilian pepper, Schinus terebinthifolius, is problem in the Park, colonizing and dominating in the farm lands released since the late 1950's (Hofstetter and Hilsenbeck 1980; Ewel et al. 1982) and in ecotonal areas of the mangrove zone. Schinus is present, but not yet a dominant species, in the bayhead and hammock tree islands. Seedlings appear to be increasing in the pinelands. Birds, and to a lesser extent mammals, have been the cause of spread of Schinus; whereas wind and water have spread the seeds of Casuarina and Melaleuca.

While these exotic species invade a variety of natural vegetation communities, their spread in wetlands is attributed primarily to the decline in vigor and health of the natural communities, mostly associated with reductions in water depths and hydroperiods (Hofstetter and Hilsenbeck 1980; Wade et al. 1980). Excess nutrients in old farm fields have played a significant role in the development of dominance by Schinus. Frequent fires, particularly in the dry season when natural fires are uncommon, have promoted the spread and establishment of Casuarina and particularly of Melaleuca (Hofstetter and Hilsenbeck 1980; Wade et al. 1980).

Future Conditions

Without the Plan

Exotic species, particularly Melaleuca, will become an incrasing environmental problem in ENP wetlands. Seeds of exotic species will continue to enter the Park, both from the East Everglades and from the Big Cypress to the northwest. Complete Melaleuca elimination from, or control in, Everglades National Park will quickly exceed foreseeable efforts and funds.

With the Plan

If the plan is instituted, the natural marsh communities should be invigorated by more favorable hydrologic conditions, and so the probability for the establishment of exotics in these communities should be reduced. Increased depths and more natural hydroperiods in the Northeast Shark River Slough will make communities there less susceptible to invasion by Melaleuca, thereby containing seed rain outside the Park.

The filling of L-67 Extension Canal will reduce the chance of introduction of water hyacinths or other aquatic weeds deep into the Park. The removal of L-67 will eliminate high ground that

the exotic tree species occupy and from which seeds are released into adjacent marshes.

Monitoring Recommendations

The primary source of invasion by exotic hydrophytes will be from the Tamiami Canal along the northern boundary of th Park (assuming L-67 Extension Canal is filled). Water release points into the Park and the northeast Shark River Slough should be monitored regularly for movement of exotic aquatic species from the canal into the marshes.

Invasion of the Park by Melaleuca and Casuarina will come from the East Everglades and Big Cypress. Casuarina sources in the lower end of WCA-3A, and the canal and road banks in the southern East Everglades will continue to pose a threat to the Park. Also, seeds of Casuarina trees on the Keys will continue to wash onto the beaches and into the mangrove forests of the Park.

Systematic surveys for exotic tree species should be undertaken every 3 years within a 6-mile strip centered along the Park boundary. The entire Park should be surveyed every 4 or 5 years. It is particularly important that Melaleuca trees be located and removed before they begin to bear fruit. The techniques of the monitoring program for Melaleuca currently used in the northern part of the Park and East Everglades will serve as a model.

Where Melaleuca has burned, the area should be examined 3-4 months and 12 months post-burn for seedlings. The probability for establishment of new seedlings of Melaleuca is very high after a fire where the sediment surface is moist, but not flooded. The Melaleuca and Casuarina monitoring program should be directly associated with the Fire Management Programs in and adjacent to ENP.

Schinus will continue to be a problem in pineland, hammocks, tree islands, and releasd farm fields throughout the Park. Because animals plan a primary role in the spread of this species, long-distance transport is more likely with this species than with the other two exotic tree species. This species is so widely established in the Park now that removal is no longer possible and control of spread is doubtful. More natural hydro-periods should slow down invasion into muhly and mixed prarie wetlands.

Development of an awareness of the severity of the problem exotic species particularly by Melaleuca, poses is needed in Park staff and an easy mechanism for reporting the sitings of exotic species.

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AN ASSESSMENT OF POTENTIAL BENEFITS TO THE ESTUARIES OF EVERGLADES NATIONAL PARK ASSOCIATED WITH THE GENERAL DESIGN MEMORANDUM TO IMPROVE WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Statement Paper

Prepared by

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May 1987

(Revised March 1990)

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ESTUARIES

Degradation

Quantitative information is not available on the resources of the park's estuaries prior to the 1920's, but general descriptive accounts by Vignoles (1823), Winter (1918), Simpson (1920), Grey (1924), Kidder (1933), and others provide insight into historic conditions. These accounts of canoe passages up the Shark River and through the everglades marshes; of coastal rookeries where the green of mangrove trees were snow white with nesting "curlews" for a half mile of stream bank, a hundred years deep into the jungle; of tarpon, snook, and bass fishing in the lower rivers; and of pockets of fresh water near the outer reaches of the estuaries, leave little doubt that many ecological changes which may be associated with upland marsh drainage and water management practices have occurred within these estuaries.

Quantitative information on changes in estuarine productivity after the 1920's is available from both bird studies and fishery studies. Information on wading bird feeding in Florida Bay, a major park estuary, suggests that the productivity of the bay, as reflected in the fish resources available to birds, has declined. Powell (1983) found a statistically significant decline in average clutch size from 3.82 to 2.88 eggs/nest for great white herons nesting in the bay from 1981 to 1984 compared to those measured by Holt in the 1920's (Holt 1928). More recently, Kushlan and Bass (1983) found that the number of osprey nesting in Florida Bay decreased 58% from 1973 to 1980. The Osprey population has remained low with variable productivity in recent years (Fleming and Kline, 1989). Bald eagle populations, which until present have remained relatively stable within the park, may now be showing signs of stress in eastern Florida Bay (W. Robertson, Everglades National Park, unpublished data). Kushlan and Frohring (1985) found that the number of nesting sites and the nesting population of brown pelicans decreased from 849 to 477 in Florida Bay from 1977 through 1982. Few, if any, white ibis (likely referred to above as "curlews"), still nest annually along Rookery Branch of the Shark River (Kushlan and White 1977).

A general decline in the sport fishery catch-rates is evident in data covering the period 1958 to present (Tilmant et al. 1987). Some of the common declining species include spotted seatrout, red drum, snook, and mangrove snapper. Browder (1985) found a general decline in the catch rate of pink shrimp on the traditional Tortugas grounds from approximately 50 lbs/hr. fished to 22 lbs/hr. fished between 1965 and 1979. Juvenile stages of pink shrimp are dependent upon the park's estuaries.

Possible Causes of the Declines

We believe that decreased upland runoff has been a major factor in these declines. A strong statistical relationship between pink shrimp catches and water levels in the Everglades at monitoring station P-35 suggests that a decline in runoff to the park's estuaries, particularly during the wet season, could result in a decline in pink shrimp abundance (Browder 1985). Robblee and Tilmant (1989) found higher recruitment of post larval pink shrimp into Florida Bay following high rainfall years. Pink shrimp have been documented as a major food item within the diets of many estuarine organisms and are believed to be a key food-chain component. Water levels are believed to be a good index of runoff (Tabb 1967). A statistical correlation between fish catch rates and rainfall for several species observed by Tilmant et al. (1987) further suggests that runoff may be an important explaining factor affecting the production of estuarine organisms. Tabb (1967) found a statistical relationship between the groundwater level in a well at the Homestead Agricultural Experiment Station and estuarine salinities.

Decreases in general water levels in the lower Everglades are documented for the period 1965 through at least 1979. These decreases may be due to less runoff from the upper Everglades into the park or may only reflect lower rainfall during the 1970's. Leach, Klein, and Hampton (1972) present evidence for a general lowering of the water table throughout the Everglades region after 1953. Groundwater levels on the lower east coast ridge declined about four feet since the early 1960's (Tabb 1987), and ground water levels in the "Frog Pond" area were drawn down to 3.5 ft. NGVD in early October from 1984 through 1986 (prior to 1984, water levels there were allowed to rise as high as 4.5 ft. NGVD). Powell et al. (1987) showed the sensitivity of demersal species in northeastern Florida Bay to changes in salinity. A major reduction in freshwater runoff to Florida Bay in the early 1900's, concurrent with the first water management actions in the Everglades, is suggested by an analysis of cores from hard corals in Florida Bay (Smith et al., 1989). Tannic acids from terrestrial vegetation, when mixed in sea water, are incorporated into coral skeletons. The intensity and extent of fluorescence within the annual growth bands of the coral is a reflection of the amount of tannic acid present at the time of growth (Isdale 1984). A distinct decrease in the intensity of fluorescence in corals from Florida Bay appears to have occurred in the early 1900's.

Changes in the Estuary due to Water Management

In general, water management during the past 25 years has brought about the following changes in runoff to the park estuaries:

1. Decreased runoff to the estuaries.

2. Change seasonal distribution of runoff.

3. Changed spatial distribution of runoff.

We feel that these changes have resulted in a general salinity change in the estuaries and, perhaps, reduced productivity. Carter et al.'s (1973) study in the Fakahatchee estuary suggests that reduced runoff can be expected to decrease the primary productivity of mangroves, the dominant coastal vegetation within the park's estuaries. Detrital export from both upland and mangrove areas can be expected to decrease with decreased runoff. Studies in the seagrass beds of Florida Bay have shown nutrients are limiting to growth and development of these grasses (Powell et al., 1989).

Altered upland runoff to estuaries has caused changes in the spatial coverage by salinities in the range most favorable to estuarine organisms. Altered runoff has undoubtedly caused an increase in the frequency, intensity, duration, and spatial coverage of hypersalinity in Florida Bay. The highest diversity and abundance of organisms in the estuary is found at middle salinities (i.e., 25-35 ppt). As conditions become hypersaline (i.e., >35 ppt), diversity and abundance rapidly decrease. Large, rapid releases of flood water through the coastal canal systems (such as C-111) directly into the estuary rapidly drop salinity to a level lower than may have occurred with slow filtering through upland marsh. This also contributes to higher salinity levels following these events without the recharge of the coastal marsh and groundwater systems that should have occurred during the storm.

Expected Benefits of a More Natural Volume, Timing, and Spatial Distribution of Runoff

Early historical accounts of south Florida, the Everglades, and the coastal estuaries clearly suggest that upland runoff and amounts of water in the Everglades marshes were once much greater than they are today. However, even under historic conditions, water levels in the marsh dropped during the dry season and drought years brought high salinities in the estuaries. High rainfall years increased runoff, holding salinities low, and hurricane floods flushed large volumes of detritus and nutrients out into the coastal bays. Natural variability was a key factor in the functioning of the Everglades system. Restoration of this natural variability and volume through rainfall linked water delivery calculations should help restore park estuaries to those conditions under which they evolved.

We believe that, historically, environmental conditions in Florida Bay, as well as Whitewater Bay and the gulf coastal rivers, were linked to hydrologic conditions within the Everglades marshes. The vast Kissimmee River- -Lake Okeechobee-

-Everglades marsh system recharged coastal ground waters and filled the transverse glades cutting across the rockland ridge to the south. Water from the south east portion of the slough flowed into Paurotis Pond, West Lake, Long Lake, Seven Palm Lake, and the upper bights of Florida Bay. Restoration of flow to the Northeast Shark River Slough is expected to largely restore the historic hydrologic connection between Shark Slough and Taylor Slough. This will, in turn, restore a longer hydroperiod in the coastal marshes on both sides of Taylor Slough. A resultant improvement in sheet flow and ground water flow through these marshes into northern Florida Bay will reduce the occurrence of hypersaline conditions in the bay.

We expect that a more natural timing of upland runoff would increase flows (relative to rainfall) during the wet season, prevent unnaturally high water releases during the dry season, and help insure a base flow of water during the late dry season. We expect these actions to result in less stress to naturally occurring estuarine organisms and higher abundances of the many organisms depending upon these animals for food. This should increase sport fish catches and the recreational enjoyment of the park.

A naturally functioning system will help reverse the declining trends in the Tortugas shrimp fishery, currently valued at approximately $1.4 million per year, and help maintain the park's recreational fishery with a direct and indirect economic value of approximately $10 million (Centaur Assoc. 1986).

We expect higher wet-season water levels in Shark Slough to increase wet-season runoff and late dry-season flow not only to Shark Slough estuaries, but also the Taylor River and other estuaries of northeastern Florida Bay. This should decrease the frequency, intensity, and spatial coverage of hypersalinity in all the coastal bays, making them more productive. Higher productivity is required for the continued maintenance of stable populations of predominantly estuarine birds, such as roseate spoonbill, reddish egret, great white heron, and osprey. Several of these species have restricted U.S. ranges of which Florida Bay is a major component.

Consequences of No Restoration of Freshwater Flow

At present, Everglades National Park estuaries are functioning at much less than their maximum productive potential. Without restoration of a more natural pattern of freshwater inflow, we will continue to see the estuaries fisheries operate at a reduced level, meaning loss of recreational enjoyment and. inevitably, visitors to the park the Florida Keys. Without improvements in productivity, Florida Bay may lose its breeding population of ospreys and Great White Herons (except for those Great White Herons dependent upon humans for their food supply). There will be a continued decline in the value of Everglades

National Park as a unique site for wildlife recreation. The estuaries of Everglades National Park are an important nursery ground for many species of fish and shellfish harvested commercially outside the park. Commercial harvest have undoubtedly been affected by a loss of productive potential in the park.

The extent of loss in productivity can only be inferred from declines in wading birds, fish eating raptors, pelicans, and sportfish. Scientific studies documenting basic rates of productivity among primary producer within the west coast estuaries are lacking and measurements are only recently available from Florida Bay (Zieman and Fourqurean). However, we believe productivity loss has had to be substantial to appear in such a wide array of higher organisms. Possibly the loss has been greatest in northeastern Florida Bay, where submerged banks reduce the moderating effect of oceanic water and extreme hypersaline conditions may have been accentuated.

Monitoring and Research

We believe that monitoring programs should be carefully designed and integrated with specific, well found research projects to generate data that can be analyzed to gain a greater understanding of functional relationships between water supply and the park's estuarine resources.

We recommend detailed monitoring on a routine, continuous, or periodic basis of salinities in the park's entire estuaries and simultaneous monitoring of upland runoff of these estuaries or some suitable index. One goal of this monitoring effort should be to develop a physical model of the estuary relating the spatial and temporal variation in salinity to freshwater inflow.

We recommend a continued monitoring program of composition and abundance of estuarine species, including but not exclusive to pink shrimp and major sport fish species. This monitoring should emphasize juvenile organisms.

We recommend continued monitoring of the catch and effort of the recreational fisheries in the Park.

We recommend further periodic monitoring of piscivorous estuarine bird populations, which are important as characteristic species of the park and are also important as indicators of the general productivity of the bay.

We recommend two related areas of research be undertaken to increase basic understanding of ecological functions within the estuary. These are: (1) comparative investigations of productivity from various locations, and (2) additional evaluations of nutrient limitations and the role of upland runoff in nutrient supply.

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EIS APPENDIX D

FINAL
FISH AND WILDLIFE COORDINATION ACT REPORT

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

FISH AND WILDLIFE COORDINATION ACT REPORT
MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK

Prepared for:
U.S. Army Corps of Engineers
Jacksonville District
Jacksonville, Florida

Prepared by:
U.S. Fish and Wildlife Service
Vero Beach Field Office
Vero Beach, Florida

March 1991

United States Department of the Interior

FISH AND WILDLIFE SERVICE

P.O. BOX 2676

VERO BEACH, FLORIDA 32961-2676

March 28, 1991

Colonel Bruce A. Malson
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Att: Regulatory Division

Dear Colonel Malson:

This document is the final Fish and Wildlife Coordination Act report on the Modified Water Deliveries to Everglades National Park. This report was reviewed and concurred in by the National Marine Fisheries Service and the Florida Game and Fresh Water Fish Commission, and constitutes the report of the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Sincerely yours,

David L. Ferrell

David L. Ferrell
Field Supervisor

Attachment w/o copy:

FWS, Jacksonville, FL
ARD, FWE, Atlanta, GA

EXECUTIVE SUMMARY

The Modified Water Deliveries Project objectives are to restore and enhance ecological characteristics of Everglades National Park and Northeast Shark River Slough by improving deliveries of surface waters.

The basic data and draft of this report were published as part of the Corps' Draft General Design Memorandum and Environmental Impact Statement, in July, 1990. Since that time the National Marine Fisheries Service and Florida Game and Fresh Water Fish Commission sent us letters generally concurring with the draft report, in accordance with their role under the Fish and Wildlife Coordination Act. The Park, as the intended beneficiary of the water delivery project had provided its preliminary views in February, 1990 (which were incorporated into the draft report), another analysis in April, 1990, in response to the preliminary draft Coordination Act report, and a final report in June 1990. The latter report was not reviewed by the Coordination Act agencies, but is attached as Appendix J.

The conclusions reached in this Coordination Act report rely on a comprehensive review of information provided by hydrological and ecological monitoring and research, expert opinion, and modeling of anticipated hydrological and biological performance of the alternatives. Modeling efforts included use of the Corps of Engineers' Surface Water Model, habitat suitability models of the endangered snail kite, endangered wood stork, and alligator developed by the Fish and Wildlife Service (Service), and wading bird and alligator population models used by Everglades National Park (Park). The Service's habitat models and the validation procedures are appended.

The Service reviewed four water delivery alternatives. These included a no action alternative (Base), a Modified Minimum alternative (using the guaranteed minimum delivery schedule and few new structures), and two raindriven alternatives. Both raindriven alternatives use a formula based on precipitation to schedule deliveries through 8 new structures. One, the Basic Raindriven, uses current water supplies and demands. The second
the Modified Raindriven, uses supplementary water and restrictions on demand to conserve water supplies in WCA3A. The three action alternatives represent initial steps towards the stated restoration goals for the Shark Slough Basin.

All alternatives were reviewed for their effect on Federally listed endangered and threatened species (Appendix A). The Service concluded that the Basic Raindriven alternative jeopardized the continued existence of the snail kite and adversely modified its critical habitat. The Basic Raindriven alternative, therefore, was eliminated from further consideration.

The two remaining action alternatives were compared to the Base (no-action) condition. The Modified Minimum delivery was found to benefit both the snail kite and the wood stork, and so best complies with Section 7(a)(1) of the Endangered Species Act. The Modified Raindriven alternative would not jeopardize either listed species, but might incidentally take snail kites. Several Reasonable and Prudent Measures were devised to protect the kite, should this alternative be implemented.

The Modified Minimum also provides the best conditions for the Miccosukee Indians to operate their concessions within southern WCA3A (Appendix D), and requires less filling and construction in wetlands than the Modified Raindriven (approximately 91 acres compared to 135 for the latter). However, the Modified Raindriven plan appear to be more conservative of water supplies in Lake Okeechobee during dry years.

Concerns about the incorporation of WCA3B into the delivery system (as under the Modified Raindriven) include loss of water through seepage, alteration and elimination of existing high quality Everglades habitat, effect on drought refugia in WCA3A, conflict with existing management by the Florida Game and Fresh Water Fish Commission, and conflict with Service's recovery goals for the endangered snail kite. However, the National Park Service has concluded that there are major ecological benefits to WCA3B from raindriven water deliveries.

Among the Fish and Wildlife Coordination Act agencies, the National Marine Fisheries Service unequivocally supports raindriven water deliveries and reservation of water for ecological purposes (Appendices L and M). The Florida Game and Fresh Water Fish Commission recommends that the Modified Minimum delivery be adopted (Appendices K and N). That is because of concern over diverting the poorer quality water from the L-67 canal across Area 3B, since this action would degrade some of the most pristine of Everglades habitat remaining. However, once nutrient reduction goals of the Everglades SWIM Plan are reached, discharge across Area 3B would be acceptable to the Game Commission. The Commission also expressed concern over elimination of fisherman access to L-67 canals by new structures (Appendix P). After the close of the public comment period on the draft documents, the Corps made several modifications to the structural design for the raindriven alternatives, partly to restore some of this access. The Commission remains concerned about loss of recreational area due to structure design. The Corps states that hydrologic impacts from these recent changes are expected to be minor, and should not affect fish and wildlife (Appendix O). In the interest of expediting the planning process, and considering that the current delivery schedule may very well be reformulated before the project is put in operation, we do not request additional model runs at this time. However, should the Modified

Raindriven Plan be selected, we believe it necessary to rerun the hydrologic model to insure that updated conditions provide the same or greater projected ecological benefits without adverse impacts.

The following recommendations were formulated by the Service, using our findings and the responses to the preliminary draft Coordination Act report:

1) Structures should be built to allow redistribution of flows across the original width of Shark River Slough. This may be accomplished as called for under the Modified Raindriven alternative, by installing 8 structures to pass water through WCA3B. Although not one of the project alternatives, the Service recommends enlarging S-333 to deliver flows directly from WCA3A through the L-29 canal into Northeast Shark River Slough, thus providing additional operational flexibility.

2) The proposed structures will provide the means of initiating the restoration process in the southern Everglades; the Service recommends that all of the proposed structures be built. It is also apparent that a raindriven water schedule will best meet the goals of the project. The operational water delivery schedule, therefore, will be based on refinement of the current rainfall formula. This refinement must consider results from modeling, iterative testing, and monitoring. The Fish and Wildlife Service and National Park Service are committed to developing an appropriate raindriven scenario that improves the timing and volume of water deliveries to Everglades National Park.

3) Further planning and modeling should be undertaken by the Corps and the South Florida Water Management District in order to resolve potential conflicts over competition for water. It is apparent that new wellfields, and even the proposed nutrient removal areas in the Everglades SWIM Plan, are likely to increase demands beyond those modelled for 1990.

4) The Park Service is currently monitoring key indicator and endangered species in the Park and Northeast Shark River Slough, and has proposed to continue a long-term monitoring program to measure responses by these species to all future operational schedules. The Service recommends implementation of supplemental monitoring efforts to cover the other portions of the southern Everglades and other ecological effects. It should include the following elements:

a) An ecological succession model should be developed for projecting vegetative changes in response to water stages, durations of flooding, and water quality, and should be validated using field data from the southern Everglades.

b) Monitoring of wood stork colonies and associated habitat factors should be undertaken in order to verify appraisals made using the habitat suitability model. Monitoring also should continue for the snail kite to verify the conclusions from that analysis. This should include at least the winter population counts (if the Modified Minimum schedule is used, or the more extensive surveys required by the Terms and Conditions of the Biological Opinion (Appendix A) if the Modified Raindriven schedule is used.

c) These data should be entered into a geographic information system, and the database be maintained for future planning and management decisions in the southern Everglades.

ADDITIONAL RECOMMENDATIONS

The Service offers the following recommendations concerning features and issues which were not dealt with in the current project alternatives but may enhance the success of the water delivery system.

1) In order to have the option of delivering water directly into Northeast Shark Slough, thus bypassing WCA3B, we recommend enlarging Structure 333 in the L-29 canal. This could satisfy the State's concerns over habitat changes in WCA3B, conserve water supplies, and add to flexibility in routing water during droughts, or add conveyance during high flow periods.

2) We are convinced that structures included under the Modified Raindriven will increase operational flexibility, <u>but it does not appear that the present water supply (both volume and timing) would take full advantage of the proposed system</u>. This situation, until rectified, will hamper efforts to restore the Everglades. In view of rapidly increasing water demands in south Florida, it is essential to identify and allocate adequate water supplies for the remaining Everglades. During this analysis the water needs of the northern Everglades (Arthur A. Marshall Loxahatchee National Wildlife Refuge, WCA2A and WCA2B) also should be considered. Therefore, the Corps of Engineers should reinitiate the Central and Southern Florida Water Supply Study for such planning purposes.

3) Restoration of a portion of the historic flow-way from Lake Okeechobee to the southern Everglades could help meet the project objectives. A vegetated flow-way could convey increased volumes, remove nutrients, and smooth transitions in timing (see Appendix E). The rainfall-driven delivery concept calls for highest volumes in wet years, when regulatory releases would be available from the Lake. The conveyance of regulatory releases to the south also would spare both the Caloosahatchee and St. Lucie estuaries impacts from excessive fresh water discharges.

ACKNOWLEDGEMENTS

The investigations forming the basis of this report were greatly facilitated by Jon Moulding, Rolando Altimirano and Lewis Hornung of the Jacksonville District, Corps of Engineers. In particular, we appreciate the time they expended on repetitive operations of the Water Management Model. Data and opinions regarding the snail kite were graciously provided by Rob Bennetts, Steven Beissinger, and Paul Sykes of the University of Florida, Yale University, and the U.S. Fish and Wildlife Service, respectively. John Ogden, Marty Fleming, and Dave Buker of Everglades National Park provided information on wood storks, alligators and topography, respectively.

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PURPOSE, SCOPE AND AUTHORITY FOR THE STUDY

Purpose: The Corps of Engineers General Design Memorandum and Environmental Impact Statement address alternative means of improving water deliveries to Everglades National Park (Park), and the resulting costs, environmental benefits, and impacts on adjacent agricultural and residential areas. This Fish and Wildlife Coordination Act and Biological Opinion discuss benefits and impacts to fish and wildlife resources in the area affected by the project.

Scope: The Park, South Florida Water Management District (District), Corps of Engineers (Corps) and Fish and Wildlife Service (Service) proposed structural and operational alternatives to meet the water delivery objectives. The area in which hydrology would be affected by these alternatives includes the Park, Northeast Shark River Slough (NESS) and two other substantial areas of historic Everglades: Water Conservation Area 3A (WCA3A) and Water Conservation Area 3B (WCA3B). The project area offers some of the most significant wildlife habitat in Florida, and totals over 1,200,000 acres. Accordingly, this is the size of the study area for determining project effects. Water budget estimates for the alternatives were based on a computer simulation (Surface Water Model) operated by the Corps, representing conditions throughout South Florida over a representative 14 year period under conditions of water demand estimated for the year 1990.

Authority: In response to PL 98-181 (Supplemental Appropriations Act of 1984), the Corps developed a General Plan for improving water delivery to the Park, and initiated the current General Design Memorandum. In 1983 the Corps, Park and the District began an iterative testing program to examine the behavior of the water delivery system, impacts to residential areas, and effects on wetlands. This testing program, with modifications, continues at the present time.

INPUT, COORDINATION AND CONCURRENCE OF: FLORIDA GAME AND FRESH WATER FISH COMMISSION AND NATIONAL MARINE FISHERIES SERVICE

We are pleased to acknowledge the information and advice proffered by Dr. James A. Rodgers, Jr. and Brian S. Barnett of the Florida Game and Fresh Water Fish Commission.

The findings in the preliminary and final drafts of this report were provided to the Commission and to the National Marine Fisheries Service for review. Both agencies responded, and generally concurred with our findings and conclusions. The Commission was complimentary about our analyses, and recommended initiating operation with a Modified Minimum Delivery schedule, to enlarge Structure 333, and to use that structure for water deliveries until the nutrient reduction goals of the Everglades SWIM Plan are met (Appendix K). They pointed out the benefit of incorporating gradual transitions in flow, rather than having sudden releases as occurred under the Base alternative. The Commission also supported the concept of a vegetated flow-way to improve water deliveries from the northern Everglades. In their response to the draft FWCA report and draft EIS, the Commission reiterated its support for the Modified Minimum Delivery (Appendix N).

In response to the most recent changes by the Corps (Appendix O), the Commission maintained their concern over water quality degradation for WCA3B, and loss of access for fishermen now using the L-67 canals (Appendix P).

The National Marine Fisheries Service provided detailed comments on March 23, 1990, followed by a clarification of their recommendations on April 3, 1990 (Appendix L). They largely concurred with our report. Of the alternatives presented, they recommended that the Modified Raindriven be used as an initial operating plan. Moreover, they proposed that the Modified Raindriven deliveries be implemented immediately, as far as the current structures will allow. The text of that letter identified a number of environmental benefits expected from improved water deliveries under the project. On August 6, 1990 the National Marine Fisheries Service commented on the draft reports. They continued supporting a raindriven delivery, but also recommended enlarging S-333 and constructing a vegetated flowway from Lake Okeechobee, both of the latter features designed to insure adequate supplies of water for the Park (Appendix M).

With the review and concurrence of these agencies this Fish and Wildlife Coordination Act Report constitutes the report of the Secretary of Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

PRIOR STUDIES AND REPORTS

This project is part of the Central and Southern Florida Flood Control project (C&SF). The Base condition includes levees, water control structures, and water regulation schedules authorized and operated under that Federal project.

A C&SF Water Supply Study was undertaken by the Corps to relate water supplies to expected demands in the project area. This investigation identified several methods of augmenting water supplies, such as aquifer storage, improved conveyance, and reverse osmosis. The study was suspended in 1989 pending a clearer need for Federal involvement.

In response to concerns about the quality, timing, volume and location of discharges to the Park ("Seven Point Plan"), Congress authorized an iterative hydrologic testing program. Since 1983, water deliveries to the Park have been carried out on an experimental basis. Monitoring of hydrological and ecological responses have been conducted by the Park, but were not available for use in this evaluation of water delivery alternatives.

DESCRIPTION OF THE STUDY AREA

The Everglades is a broad shallow wetland originally extending from Lake Okeechobee to the mangrove zone at the southern tip of Florida. Location of peat deposits at the southern end of Lake Okeechobee indicates that the Lake was hydrologically connected with the Everglades in the past (Stone et al. 1989).

All of the historic Everglades have been affected by the complex of canals, structures, pumps and impoundments known as the Central and Southern Florida Flood Control Project (see Figure 1). The Park lies at the southern terminus of that vast system. With the completion of Water Conservation Area 3A (WCA3A) and the southward extension of levee 67 in the 1960's, the natural flows to the Park became subject to water releases by regulation schedule. Discharges were based on the competing needs to retain water for urban and agricultural use during the dry season, to maintain flood control capacity, and to prevent water from reaching stages which might endanger the levees. Following severe impacts to the Park from droughts in the late 1960's, Congress imposed a requirement that a minimum discharge schedule be met to assure survival of Park wetland communities. This "Minimum Delivery Schedule" thus is the Base condition or no-action alternative to be considered when reviewing water delivery scenarios.

Park scientists recognized that the minimum guaranteed supply addressed only one aspect of water delivery. The scheduling of flows still was based on needs of other consumers and the requirement of disposing of excess water. Stages in the Park occasionally were caused to increase during the dry season, disrupting nesting and feeding patterns of reptiles and birds. Moreover, the delivery of water from WCA3A was directed to the west side of the main channel of Shark River Slough, distorting stages in the Park and abbreviating

the hydroperiod of NESS. According to the Park, these changes have had the following effects:

> Reduced hydroperiods, as in Northeast Shark Slough (NESS), changed a formerly rich, central slough habitat into a degraded marsh with low-standing stocks of aquatic animals. Dry season flood releases into ENP disperse prey concentrations, disrupting wading bird feeding and nesting; and, the shift of flow from east to west causes the annual northern Shark Slough dry season pool to form outside the main channel of the slough where it is less persistent and less productive. Diversion of water from NESS and operation of L-31N and L-31W canals have resulted in drier conditions in the eastern rocky glades and Taylor Slough headwaters -- important dry season feeding areas for wading birds.

Therefore, the overall project area encompasses the Park, NESS, and also the two Water Conservation Areas through which water would be delivered.

PROJECT OBJECTIVES

The basic objective of this Modified Water Deliveries project is to improve hydrologic conditions essential to maintenance of Everglades habitats. The Park has noted:

> The ecological integrity of the Everglades ecosystem has declined over the past several decades. This is evidenced by a 90% decline in the number of nesting wading birds, significant changes in the historical distribution and abundance of higher trophic level consumer populations within the system, reduced hydroperiods, loss of marsh productivity within the eastern marsh areas, increased frequency of alligator nest flooding, and overall loss of wetland habitat. The general health and continued survival of native wildlife populations within Everglades National Park is at risk unless restoration of natural functioning ecological processes can be attained.

These concerns led to an experimental water delivery testing program in 1983, and planning for a Federal project to enhance deliveries. However, the exact objectives of the Federal project have been perceived in different ways by different agencies, resulting in some confusion and conflict. Our understanding of the objectives of the interested agencies is as follows.

Everglades National Park: The Park's objectives stated in a memorandum in March 1987 were:

1) Mitigate high water releases to Shark Slough through the S-12 structures, especially during normal dry season recession periods.

2) Restore flow distribution across the entire width of Shark Slough (roughly L-30 to 40-Mile Bend). This would not only contribute significantly to goal 1, but would also help restore hydroperiods in the eastern portion of the historic Shark Slough Basin.

3) Allow volume and timing of deliveries to fluctuate as they did historically in response to rainfall and antecedent conditions in the southern Everglades.

4) Maintain downstream Shark Slough water levels at pre-project levels.

5) Maintain water quality so that resource degradation does not occur.

In a February 1990 report on this project the Park restated their goals:

1. Allow the volume and timing of all surface water flows through the Water Conservation Areas and Everglades National Park to fluctuate naturally in response to rainfall and antecedent hydrologic conditions.

2. Restore natural surface water flow patterns within Water Conservation Areas 3A and 3B and a return to pre-project flow distributions across the entire width of the Shark Slough Basin.

3. Mitigate the detrimental downstream effects of large regulatory releases into western Shark Slough by diverting excess stormwater in WCA 3A into WCA 3B and Northeast Shark Slough.

4. Restore surface water depths and hydropatterns throughout the Southern Everglades to correspond with the natural soil and topographic conditions found in each basin.

5. Improve and maintain the quality of waters flowing through the Southern Everglades, so that the natural resources of the area are not altered or degraded.

The Park apparently has increased emphasis on changing the conditions within the Water Conservation Areas. However, these areas are not under Federal management, but are the responsibility of the Florida Game and Freshwater Fish

Commission, which is the State Fish and Wildlife Coordination Act agency. Also, arguments for "restoring" shorter hydroperiods in WCA3A are somewhat countered by the fact that long hydroperiods are consistent with the occurrence of peat soils, which form an arc across WCA3A and through WCA3B, then back across NESS and southwest. Therefore, the slough condition in southeast WCA3A is only slightly "unnatural". Moreover, it replaces the deep slough (evidenced by water lily peat) formerly lying further to the east, which has been permanently lost due to drainage and development.

The Park's recently stated objective number 4 also appears to be in conflict with needs of Federally listed endangered species and maintenance of their Critical Habitats (see Biological Opinion, Appendix A). Those objectives consistent with requirements of the Endangered Species Act will be addressed in this report.

The Corps of Engineers: The Corps' project objectives have been to restore historic hydrologic conditions within the Park. These include the timing and duration of flows, and the spatial distribution of surface water. However, there is no documentation of the natural hydrologic conditions or historic water levels in the Park. As a result, those advocating restoration of historic conditions have had difficulties in specifying the preferred water delivery conditions and in identifying the associated environmental benefits and impacts.

The Corps' "General Plan for Implementation of an Improved Water Delivery System to Everglades National Park, Florida" (1985) notes that timing and duration of flows can be improved by two approaches: 1) varying the rates of water deliveries according to rainfall and stage conditions upstream of the Park, and; 2) manipulating water deliveries according to ecological conditions desired in the Park. These two ideas gave rise to two groups of water delivery alternatives: the first based on a formula reflecting runoff from rainfall north of the Park; the second based on the guaranteed minimum schedule.

It should be noted that regulatory releases (to protect the Water Conservation Area levees) are superimposed on the scheduled flows, and often comprise the majority of discharges sent to the Park. Also, in time of drought, the deliveries to the Park may be reduced below those called for by schedule. Thus, all of the alternatives are compromised by "real-world" limitations.

Other Corps-specified project objectives were to smooth the transitions between wet and dry periods, to restore the spatial distribution of flows across Shark River Slough, and to provide "ecologically desirable" volumes of water to the Park.

Fish and Wildlife Service: The Service objectives for this project generally complement those of the Park. The objectives are to protect and enhance fish and wildlife and their habitats. Typically, the Service focusses on priority species, or those which are indicators of habitat condition. There is, of course, always an emphasis on Federally listed endangered and threatened species, which could be affected by the project.

In cooperation with Park scientists, the Service selected three species which represent not only the spectrum of hydroperiod conditions in the Everglades, but also are inherently of special concern. These are the wood stork, the snail kite, and the American alligator. Accordingly, the Service's planning objectives include:

1) Implement recovery actions for endangered wood storks and other wading birds, such as protection and enhancement of feeding areas within range of rookeries. Forage production and availability depends on adequate flooding of wetlands and proper timing of drying events, respectively. As a result, the wood stork is a sensitive bio-indicator for seasonally flooded Everglades conditions. Actions to benefit the stork and wading birds include:

a) reducing the occurrence of stage reversals during spring drying, such as may be caused by regulatory releases from the WCA's;

b) expanding the extent of seasonally flooded wetlands, yielding a continuum of hydrologic conditions suitable for foraging during the entire nesting season;

c) lengthening hydroperiod of the main stem of Shark River Slough, providing a dry season refugium for forage fishes from which they can restock shorter hydroperiod wetlands.

2) Maintain or enhance snail kite habitat. Much of the study area (WCA3A and Park) lies within the designated Critical Habitat for this endangered species. Kite habitat represents the longer hydroperiod spectrum of Everglades conditions. Other wildlife components of this community include crayfish and apple snails, larger species of fish, amphibians, alligators and turtles. Sloughs also serve as foraging areas for wading birds and mammals in the dry season or low rainfall years. Management actions should include:

a) protection and enhancement of nesting habitat. Kite nesting occurs presently within WCA3A and WCA3B. Lengthening hydroperiods in NESS (to 2 - 6 years) could expand this range (Bennetts et al. 1988);

b) protection of drought refugia. Kites disperse when normal feeding areas dry up, and high mortality occurs as they search for subsistence habitats. Maintenance of persistent pools of shallow water within the Everglades can reduce the damage from drought events to this species.

3) Avoid significant reduction in alligator habitat. The alligator is a "keystone" species. It modifies wetland habitats while creating ponds, dens, trails and nest mounds, which in turn affects habitat suitability for other Everglades species. Alligators are relatively abundant in the Everglades because of their longevity and adaptability. Maintenance needs include:

a) persistent ponds or sloughs to assure that larger forage organisms can weather drought events;

b) adequate extent of flooded habitat to produce forage;

c) relatively dependable seasonal flooding and drying progressions (especially rising water levels in late spring/early summer) to insure nesting success.

4) Secure adequate water supplies for the long-term maintenance of fish and wildlife habitat in the Everglades. This should include planning for improving conveyance, storage, and allocation of water among the various consumers.

Additionally, the Service is in agreement with Park concerns over the more general protection and restoration of Everglades habitats. Therefore, a final objective is to:

4) Maintain hydroperiods and water quality necessary for indigenous wetland communities. Hydroperiods and seasonal timing of flooding control vegetation directly (tolerances of plants to inundation) and indirectly (fire frequency, competition by invading species). Nutrient levels also can control species composition and densities of Everglades vegetation. "Natural" hydroperiods and water chemistry would, of course, tend to maintain historic vegetation (and thus soil) conditions. This objective should be met insofar as it is compatible with other requirements and constraints.

Water Supply and other Constraints: In addition to constraints imposed by land ownership and cost, the range of project alternatives was limited by the need to maintain water supplies and stages for other users. The Corps' hydrologic

modeling incorporated a certain level of water supply and demand, representing the conditions for the year 1990. While some such estimate must be made, it appears fairly certain that water demands ultimately are likely to exceed water supply, raising the level of competition between users.

Lake Okeechobee supplies water to WCA3A, with deliveries depending on Lake stage, upstream withdrawals (primarily by agricultural users), and canal stages. One constraint, therefore, was to avoid having adverse impacts on the ecological condition or water supply of the Lake. Similarly, WCA3A serves as water supply for Miami and south Dade County. Therefore, another constraint was to avoid significant reduction in water supply for existing users, downstream.

Water Conservation Area 3A is used by the Miccosukee Indian Tribe for maintaining their traditional way of life and as the location of an airboat concession. Lowering water stages at the south end of WCA3A are adverse to the Tribe.

A final consideration is the complexity of building and operating the project structures, and the extent of filling and other loss of wetlands. These project impacts are estimated and tabulated below.

DESCRIPTION OF EVALUATION METHODS

Ecological aspects of this project have been investigated using two general approaches. In one, structural and/or operational changes are made, and researchers monitor responses of community components. While this approach is most realistic, the experimenter cannot control or separate effects from incidental changes (such as rainfall variation) from those due to the experimental actions. Therefore, one cannot attribute ecological responses to the deliberate manipulation. Also, in a unique system such as the Everglades, one cannot have controls to test operational changes against, nor run several alternatives simultaneously to reduce variability of findings. Findings from the first seven years of the experimental water delivery in Shark River Slough were not available to the Service, in any case.

A second approach is ecological modeling. Model results are inevitably approximations of the real world, but they are ideal for planning purposes. Modeling takes advantage of information derived during research and monitoring, and allows one to "iteratively test" effects of intended manipulations one at a time or in combination.

In order to carry out our responsibilities under the Fish and Wildlife Coordination Act, we computed project effects by using Habitat Suitability Index models (U.S. Fish and Wildlife Service 1980). Evaluation species were selected in cooperation with staff of the Park in July 1988. Each evaluation species model (wood stork, Banner 1989; alligator, Banner 1990; snail kite, Banner and Sultzman 1988) was developed or revised, and validated using data from the southern Everglades. The species models are described in the Appendixes; their application and outputs are discussed below. Our analysis compared environmental conditions and associated habitat values for the proposed action alternatives to those for the Base condition (the no-action alternative). Potential carrying capacity of habitats in the study area were expressed in terms of a Habitat Suitability Index (HSI), scored from 0 (unsuitable for the species) to 1.0 (optimum habitat).

The Park conducted its own analysis of the water delivery alternatives under consideration and also a hypothetical "natural" water flow regime. Their analysis of the action alternatives and Base used the same data output, but was based on their own suite of models. The Park's findings also are presented in the following sections, as they relate to the listed objectives.

All of the major changes from this project are of a hydrologic nature, and it is widely recognized that stage, duration and timing of flooding events have a profound influence on the Everglades ecosystem. Fortunately, a Surface Water Model was developed by the South Florida Water Management District for the Central and South Florida Flood Control Project. This was the primary source of predictive information about water stages which are likely to occur under all project alternatives. The model was operated by the Corps and the data, representing conditions as they would have occurred under each project alternative, were provided to the Service and the Park. The model subdivides most of south Florida into a grid of cells, each 2 miles by 2 miles (Figure 2). Water stages are computed for each cell on a daily basis, but were provided to us as end of month stages for each of the 14 years in the period of record. The Corps also provided data processed in terms of hydroperiod and average flooding conditions. This data reduction was necessary to deal with the long period of record and a study area covering over 1,200 square miles.

Examination of the spatial distribution of water was done by plotting the hydrologic data from the Surface Water Model runs in a spreadsheet formatted to represent the actual locations of the data points. Thus, the spreadsheet served to geographically display the information, on a cell by cell basis.

Two such data displays were most informative for interpreting the general trends from the alternatives. The first is a map showing percent of the 14 year period of record that water depth would be 5 cm or more deep. Such a display

illustrates both the extent and duration of flooding, both of which tend to be associated with the extent of production of forage organisms.

The second type of map shows the average duration of flooding intervals, or the time between drying events, over the 14-year period. This display is particularly relevant for locating the hydroperiod conditions preferred by different organisms, including vegetation, fishes, wading birds, alligators and snail kites. In a general sense, longer hydroperiod wetlands tend to be more productive of forage organisms and larger fishes, while shorter hydroperiods indicate areas which dry and concentrate fishes, making them available to predators on a seasonal basis.

MATERIALS AND METHODS

Topographic information: A topographic map of the project area is provided in Appendix F. It was based upon data used in the Surface Water Model (average ground surface elevation by grid cell), supplemented by survey data collected for the Park, primarily within NESS.

Data sources: Data on the project area and the species of concern were derived in part from studies by the University of Florida. These included 1) a field survey of vegetation in the area where WCA3A, WCA3B, NESS and the Park adjoin (Tanner et al. undated); 2) ecological studies of wading birds in the southern Everglades (Frederick and Collopy 1988); 3) a study of the snail kite in WCA3A (Bennetts et al. 1988); and, 4) a massive analysis of general hydrological, geological and vegetation conditions in NESS and the Park (Tropical BioIndustries, Inc. undated). These studies were extremely useful in identifying factors significant to the respective biota and maintenance of soils, and indicating expected trends in response to altered hydrology.

An analysis of environmental effects from water management in WCA3A was provided in Schortemeyer (1980). This dealt with factors that affect wildlife indirectly (such as peat subsidence and fire frequency), and also directly (optimum water stages for several types of wetland plants and animals).

The Park provided an analysis of hydrologic conditions and wildlife values under historic and modern water regimes, as well as analysis and discussion of potential impacts from proposed water delivery alternatives. The Park's observations are incorporated in this current report.

Hydrologic data were provided to us from "runs" of the Corps' Surface Water Model. We also interpreted aerial photographs and relied on published field surveys. Information on vegetation and soil conditions was derived from a

relatively sparse network of samples. However, since these conditions were considered to remain constant under the project evaluations, this was unlikely to affect the evaluation of the alternatives.

The study area was subdivided into convenient subareas which could be characterized using available photography and information from long-term water level stations. Data for each of the 40 cells analyzed for the snail kite and alligator were attributed according to the subarea they occupied.

Lexicon of model variables: A lexicon describing the variables used by the snail kite and alligator models is provided in Appendix I.

MODEL VALIDATION

The three species models were developed using the literature and expert opinion (Banner 1988, Banner 1989, Banner 1990). The draft models then were operated on data sets obtained in the southern Everglades, were revised to improve agreement with actual species responses, and were accepted once model outputs showed significant correlation with additional data sets.

Snail kite:

The snail kite population in Florida is believed to be limited by the availability of refugia during drought events (S. Beissinger, pers. comm.) rather than by the quality of nesting habitat. Certainly, the population has been drastically reduced during severe droughts. For this reason the Endangered Species Act Biological Opinion (Appendix A) focussed on the frequency of drying events and availability of habitat during droughts. However, kites actually spend more time in "primary habitats" (as described in Beissinger and Takekawa 1983), where typical maintenance and reproductive activities take place. Primary habitats tend to be relatively long hydroperiod wetlands, which support apple snails. Because this snail is an important forage organism in Everglades food chains (Kushlan 1975), the suitability of such primary habitats for kites also reflects their value to other wildlife (limpkin, alligator, bass, turtles, ibis). Therefore, the HSI model for the snail kite was designed to identify the value of wetlands for foraging, roosting and nesting by kites.

The kite model (Appendix B) was tested and revised using data on the distribution and success of nesting birds. The field data were obtained from Bennetts et al. (1988), reporting on a two-year study of snail kite nesting in the south end of WCA3A. These data and discussions were most useful to the application of the kite model, and vital to its validation. Output from the snail

kite habitat model was compared to the number and success of nests found by Bennetts et al (1988), in 92 grid cells, each 4 sq. mi. in area.

Hydrologic data were derived from the validation run (historic conditions) of the Corp's Surface Water Model. The Model's period of record, 1969 through 1982, was extended through 1986 (the time of Bennetts' observations) in the following manner: for each cell in the area of interest end-of-month stages from the model were compared to those from the nearest recording gauge. Monthly differences were aggregated to determine wet season and dry season relationships, based on data available for the period 1980 through 1982. This relationship then was applied to more recent gauge readings in order to calculate what the stage for each cell would have been had the model run been continued.

Values for the hydrologic variables in the kite model were computed by comparing ground surface elevations and water stages. Values for vegetation characteristics and other variables were derived from interpretation of aerial photographs. The snail kite study by Bennetts et al. (1988) included an image derived from the "SPOT" satellite, classified to show tree islands, open water and sawgrass within the nesting areas used by the kite. They found that kites nested in the southern portion of WCA3A where open water ranged from 12% to 67%, and averaged 32%. The regions not used for nesting had significantly less open water. Vegetation densities based on photo-interpretation for the present study agreed with those values and their distribution.

Numbers of nests per cell and model output (HSI value) showed a significant correlation ($p = .00014$). The number of young fledged per cell also correlated with HSI ($p = .00046$). However, nesting occurred only in cells with HSI's of 0.5 and over (Figure 5). This gives the appearance of a "threshold" for nest site selection. This outcome may in fact be appropriate for several reasons. First, the kite's home range is generally less than 2 km (Sykes 1985), and foraging conditions need to be adequate in this area during the period the bird tends the nest. Therefore, birds should be more demanding of quality habitat while selecting a nest site than during non-reproductive periods. In fact, Bennetts et al. found that kites do not appear to nest in the same locations in succeeding years, and suggested that depletion of prey was the reason. Second, the fact that kites limit nesting during drought conditions also indicates the existence of a reproductive threshold dependent on environmental quality. In summary, model output agreed with observed habitat use, and the areas rated at HSI = 0.5 or better appear to be suitable for nesting by kites.

<u>Wood stork:</u> Storks using the project area include relatively large numbers of wintering birds, which may nest in north Florida, Georgia, and South Carolina and far fewer birds resident in colonies of the southern Everglades. To deal

with needs of the resident birds the Service developed a model specific to the Lane River and Cuthbert Lake wood stork colonies in Everglades National Park (Banner 1989). The model is based on hydrologic parameters reflecting conditions for the years 1969 through 1982, and the associated success or failure of wood stork nesting efforts (see Appendix A in the attached Biological Opinion). Model results were significantly correlated with numbers of birds nesting per year.

The habitat suitability model applicable to this study area, therefore, consists of output based on the HSI graph (Figure 6). Output for each year's hydrologic data is averaged for the period of record, and these averages are used to compare the project alternatives.

Alligator: The American alligator model focusses on hydroperiod as it affects the prey base for subadult and adult animals. This is supplemented by the Park's analysis regarding the relationship of hydrology to population dynamics.

The Alligator model was developed in consultation with species experts, using a "blue book" HSI model as a base (Newsom, Joanen and Howard, 1987), and modifying it using observations from Florida studies. It was tested by calculating HSI values for 83 4-square mile grid cells within the Park and NESS (Figure 7, training cells), based on hydrologic conditions for 1969 through 1982 from the validation run of the Water Model. These were compared to the number of ponds with alligator trails (courtesy of M. Fleming, ENP) per cell, and the model was modified to better fit these 1985 data. While a more current data set was desired, occupancy of the ponds probably reflects water conditions from past years.

Numbers of occupied ponds per cell were indexed to the local maximum (assumed to be carrying capacity). Suitability index curves were adjusted to agree with the field data, as interpreted by G. Dalrymple (pers. comm.). As a result, the importance of hydrologic variables increased relative to vegetation by combining them in a weighted geometric mean, and the revised model (version 1.2a; Appendix C) was tested on 36 other cells in the study area (Figure 7, test cells). The results are given in Table 1, and graphed in Figure 8. The analysis suggests that while many of the cells are below carrying capacity, peak occupancy does increase with computed habitat suitability (significantly correlated at $<.05$).

APPLICATION OF THE MODELS

The study area included a very large portion of the remaining Everglades. The boundaries were selected to encompass wetlands which likely would be

hydrologically affected by the project, and other habitat the value of which is dependent on conditions in the areas directly affected. For example, wood stork utilization of colonies near Florida Bay is affected by the availability of supplementary feeding grounds further to the north, within the range of direct influence from the project. Therefore, the colony sites were included in the study area even though direct hydrologic changes are not anticipated at that distance.

The wood stork model utilized data from all grid cells in that part of the study area within range of the Park colonies (Figure 9). The alligator and kite models were operated by taking 40 cells (Figure 10), representative of the study area, and comparing Habitat Suitability Index values under the four alternatives. This sampling procedure disclosed impacts/benefits in all parts of the Water Conservation Areas, NESS, and the Park.

PROJECT ALTERNATIVES

The original project alternatives were: 1) the no-action condition (Base), and; 2) plans involving construction of levees and water control structures which could be operated according to a range of delivery schedules. Initially, two water delivery schedules were considered. One was based on a formula reflecting rainfall patterns and amounts in the headwater regions for the Park (Raindriven Plan). The other left all structures open, and flows occurred in response to gravity drainage. The latter plan (Flow-through) was abandoned early in the planning process because of its lack of control and because it tended to overdrain WCA3A.

Review of the initial Raindriven Plan indicated that it could adversely affect the endangered snail kite (Bennetts, et al, 1988). As a result of a meeting in February 1989 between the Service, Corps, Park, SFWMD, the Service was given the charge of developing at least one new delivery alternative which would allow the objectives to be met without jeopardizing this species. In cooperation with the Corps, the Service tested approximately 10 versions of water delivery plans, and produced two which would not severely impact the kite.

Prior to completion of consultation under the Endangered Species Act, four project alternatives were under consideration. The first was the Base condition. The second (Modified Minimum Delivery) most simply enhanced ecological conditions in the Park and neighboring wetlands. The third was based upon restoration of natural flows to the Park (Basic Raindriven Plan), and was the subject of concern during early consultation on the snail kite. The fourth also

used a rainfall formula for natural water deliveries, and added supplementary flows needed for maintenance of upstream habitats (Modified Raindriven Plan).

Base Condition: The no-action alternative would make use of the current water delivery structures. Under the Base, water is delivered according to a formula approved by Congress in 1970, and designed to guarantee at least a minimally adequate flow into the Park. All other alternatives require installation of new structures and management plans.

Modified Minimum Delivery: This is the simplest action alternative both structurally and operationally. New features would include elimination of the levee (L-67x) separating the "chimney" of the Park from NESS, replacing it back into the adjacent canal (see Figure 11). This would allow water to spread eastward, into NESS. A flood protection levee would be built around the residential portion of NESS, and drainage would be provided by pumping into the L-29 canal. Water deliveries to the Park would be the same as under the Base condition.

Basic Raindriven Plan: The Basic Raindriven alternative also removes the L-67x levee and installs flood protection levees and pumps. Additionally, six gated structures would be installed in WCA3A to reduce canal conveyance to the south (forcing water to spread out more extensively), and to divert most of these flows through WCA3B. Two additional structures would send water south out of WCA3B, into NESS.

A more recent proposal by the Corps would install boat-bypass canals in the marsh, around the tie-back levees WCA3A. The structures would also be placed further apart, to spread out deliveries into WCA3B. These changes were not incorporated in the hydrologic model runs used in the following analyses; however, the Corps believes that hydrologic impacts from these recent changes should be negligible.

Under the Basic Raindriven Plan water is delivered to the Park using a formula based on precipitation in the basin upstream of the Park. This means that flows can vary widely. In droughts (typically at 5-7 year intervals) water deliveries may cease entirely (as occurred throughout most of 1989, under experimental raindriven operations). The Service's Biological Opinion found that this alternative would jeopardize the continued existence of the snail kite (Appendix A). Therefore, it was eliminated from further consideration.

Modified Raindriven Plan: Because hydrologic modeling of the Basic Raindriven plan showed significant drainage of WCA3A, the Corps and the Service developed a Modified Raindriven Plan. This alternative uses the same structures as the Basic Raindriven Plan, and delivers water to the Park

according to the same formula. To conserve water in WCA3A, the Modified Raindriven Plan does not use the obstructions in the L-67x canal, but does have the connections with WCA3B. Also, during droughts, water consumption from WCA3A is cut back, and supplemental deliveries from Lake Okeechobee are initiated at an earlier stage. However, because the schedule of deliveries to the Park is controlled by local rainfall, the overall water demand on Lake Okeechobee is lower than under the Base Plan, especially in drought years (Appendix A, Figure 1b).

RESULTS OF ANALYSES

The overall results of the analyses are summarized in Table 2, and discussed below.

1) Moderation of unnatural flow events: One of the project objectives is to reduce ecological damage resulting from sudden releases of high volumes of water. The Park's analysis found that:

> The Base (BA) and Modified Base (BC) alternatives produced abrupt seasonal spikes with rapid flow increases occurring each year between July and August, regardless of the timing of local rainfall. In contrast, flows under the Basic Rain-Driven (MU) and Modified Rain-Driven (MP) alternatives show a more gradual rise in response to the start of wet season rainfall (reduction in abrupt spikes) and the timing of these flows varied annually in response to the observed rainfall conditions.

The impacts from such flow events are tempered by dissipating flooding across a broad front. The Modified Minimum does this to a degree, allowing flows from the S-12s to run towards NESS. The Modified Raindriven does this more directly, discharging directly into NESS. The combination of a transition zone in the release schedule and redirection of flows strongly improves the performance of the latter alternative.

2) Rediversion of flows into NESS: This Park objective of redistributing flows is best met by the Modified Raindriven alternative. This alternative includes new structures to move water between WCA3A and WCA3B, and then directly into NESS. The proportions of water delivered across the eastern (NESS) and western (Park) boundaries and the respective volumes are given in Tables 3 and 4, produced by the Park.

3) Timing of water deliveries: The effects from seasonal variations in water levels are reflected in results from the wood stork model and the Park's wading bird model. Both showed that the Modified Minimum delivery produced the

most beneficial conditions. However, the Park found that water deliveries had more natural timing under the Modified Raindriven alternative:

> In the absence of large regulatory releases, flows under the Base (BA) and Modified Base (BC) alternatives consistently peaked in October and decreased at a fixed rate through January. In contrast, under the Basic Rain-Driven (MU) and Modified Rain-Driven (MP) alternatives, the timing of wet season peaks and length of the recession curves varied each year in response to the cessation of rainfall.

4) Restore stages in ENP and NESS: The Park examined the extent of flooding and hydroperiod, and interpreted those according to various depth classes. They compared the performance of the alternatives during the wet season (June through November) and dry season (December through May) of each year, as well as overall statistics for the 14 year test period. The water depth classes were:

1. Dry - percentage of the area with water below ground.

2. Transitional - percentage of the area with surface water from 0.0 to 0.5 feet deep.

3. Shallow - The percentage of the area with surface water from 0.5 to 1.0 feet deep.

4. Deep - The percentage of the area with surface water in excess of 1.0 feet deep.

A similar series of tables placed the results in five hydroperiod classes for the four sub-basins for each hydrologic year (June through May) and the overall statistics for the 14 year test period. The hydroperiod classes were defined using the following criteria:

1. Category 0 - The percentage of the area with surface water inundations lasting less than one month.

2. Category 1-3 - The percentage of the area with surface water inundations lasting from 1 to 3 months.

3. Category 4-6 - The percentage of the area with surface water inundations lasting from 4 to 6 months.

4. Category 7-9 - The percentage of the area with surface water inundations lasting from 7 to 9 months.

5. Category 10-12 - The percentage of the area with surface water inundations lasting from 10 to 12 months.

Their summary statistics are given in Tables 5,6,7 and 8. The Park's findings with respect to water depth distributions in NESS and central and western Shark Slough are discussed below.

Northeast Shark Slough - The Park found that both action alternatives showed an overall increase in water depths compared to the Base. The Modified Raindriven alternative was the most effective of the alternatives at restoring deep water conditions in NESS. In an average wet season the deep water depth class was increased by 29 percent. Under average dry season conditions the maximum area of inundation for all three of these alternatives was nearly identical (approximately 50 percent), but the Modified Raindriven alternative maintained the highest percentage of the area in deep water. In dry years Park maps show that the Modified Raindriven produces a larger deep pool than the Modified Minimum. Both action alternatives substantially reduced the percentage of NESS which completely dried, when compared to the Base. The Park also mapped hydropatterns in order to examine differences in the spatial patterns of these variables under the four proposed alternatives. The maps indicate that none of the alternatives maintained surface water conditions in NESS during severe drying conditions.

Under high wet season rainfall conditions, such as June 1969 through May 1970, the majority of the NESS Basin would be covered by deep water under all of the alternatives. The action alternatives showed nearly identical water depth conditions, and produced a 14 percent increase in deep water over the Base.

Central and Western Shark Slough - Under average wet season conditions both action alternatives showed only slight changes in overall water depths when compared to the Base (Table 7). Park mapping indicates that the Modified Raindriven alternative is much more effective at maintaining a central core of deep water from NESS to the downstream estuaries under these hydrologic conditions. In contrast, the Base and Modified Minimum alternatives produced nearly equal percentages of deep water, but these areas occurred in isolated pools. Under average dry season conditions the action alternatives showed an overall decrease in water depths, compared to the Base.

Under below normal dry season conditions, the Modified Base and Modified Raindriven alternatives substantially reduced the percentage of the basin that dried completely.

5) Extent of flooding: Figures in Appendix F show the percentage of the time that each cell was flooded by more than 4 cm of water during the 14- year

period of record. For ease of comparison, the Base percentages were subtracted from the percentage under the action alternative for each cell was subtracted. Figures 12 and 13 show the differences in percent of time flooded between these alternatives and the no-action condition. The larger positive numbers indicate increased flooding, while the negative values show reduced percentage of the time flooded.

The Modified Minimum causes very minor changes in WCA3A, some increase in flooding in WCA3B, minor but extensive decrease in flooding in the Park, and a significant increase in flooding in NESS (locally, about an additional 10% to 30% of the time).

The Modified Raindriven shows minor but extensive increases of flooding in WCA3A, mixed effects in WCA3B, reduction of flooding in the Park, and very sizeable increases of flooding in NESS (locally, about an additional 15 to 50% of the time).

These results also were summed to show the average percent of time flooded for cells in WCA3A, WCA3B, NESS and the Park (Table 2).

6) Wood stork habitat model: Table 9 gives the HSI values for the study area by year, for the three alternatives, and the average values for the 13 years analyzed. The averages also are graphically displayed in Figure 14. The HSI values were arcsin transformed, and the action alternatives compared to the Base using a t-test. The Modified Minimum was apparently better than the Base, but not significantly. The Modified Raindriven was significantly worse than the Base ($p < .01$).

7) Park wading bird model: The Park also performed modeling of wading bird colony nesting success for the alternative deliveries. As with the above wood stork results, they also found that the Modified Minimum would lead to higher nesting success than the Base, and the Modified Raindriven lower (Table 10a).

8) Snail kite nesting habitat: Figures 15, 16, and 17 show the HSI values for the 40 cells sampled within the study area. The Modified Minimum shows the same values as the Base, while the Modified Raindriven improves nesting habitat in WCA3A and NESS. However, the Base has higher HSI's along the western side of Shark River Slough.

These HSI data are brought together in Table 11. Results for the three alternatives were examined statistically using t-tests on arcsin transformed data pairs. Overall, the Modified Minimum is virtually the same as Base, while the Modified Raindriven offers better nesting conditions, but not significantly. Averages of these HSI values are graphed in Figure 18.

9) Hydroperiod: Maps of hydroperiod (average duration of flooding intervals, in years) are given in Appendix A and in Appendix F. The Base condition and Modified Minimum are very similar. Central WCA3A has average hydroperiods of 1 to 1.5 years, and up to 7 or 14 years (continuous flooding) along the southeastern boundary. Hydroperiods in WCA3B are up to 2.2 years, and the "chimney" of the Park is about 1.5 years in the Base, but up to 3.4 years in the Modified Minimum. NESS hydroperiods are slightly increased with the Modified Minimum.

The Modified Raindriven spreads water out in WCA3A, lengthening hydroperiods in the center, but reducing them along the southeastern boundary. Hydroperiods in WCA3B are actually reduced somewhat (even though it is in the flow path), the Park sees little change, while values in NESS are higher than Base or Modified Minimum.

The amount of habitat available for wetland dependent wildlife in drought years is depicted in Figure 8 of Appendix A. This shows that the Base and Modified Minimum offer refugia in all years, while the Modified Raindriven caused complete drying of the southern Everglades in one of the 14 years examined.

10) Alligator habitat suitability: Figures 19, 20, and 21 display the HSI values for the 40 sample cells under the three alternatives. The differences are very slight; only cells within NESS show notable increases under the action alternatives. These results are tabulated (Table 12), and graphed (Figure 22). The Modified Minimum is slightly (but not significantly) better than the Base.

11) Park analysis of alligator responses: The Park performed modeling of alligator population parameters for the project alternatives; their analysis is given in Table 10b. They also found only very minor differences. Population estimates averaged slightly higher under the Modified Raindriven, but this alternative had a slightly lower level of nesting success than either Modified Minimum or Base.

12) Effects on Miccosukee Indian use of WCA3A: The Indian's ability to operate their airboat concession in WCA3A is dependent on water stages being at or above 7.4 feet NGVD (see Appendix D). Both the Modified Minimum and Modified Raindriven alternatives improve the accessibility of WCA3A to the Indians, with the former schedule being considerably better (see Table 2).

13) Effects on Lake Okeechobee: A series of figures in Appendix F show the relative effects of the three alternatives on Lake Okeechobee stages over the 14 year period of record. The Modified Minimum delivery has the same demands as the Base, and so no changes occur. However, the Modified Raindriven actually requires fewer releases from the Lake during dry years, and more in

wet years (see Figure 1b, Appendix A). This results in slightly higher Lake stages, and more plentiful water supply for other consumers.

14) Other project impacts: The Modified Minimum plan calls for construction of a flood protection levee, pump station and removal of Levee 67x. This construction will eliminate approximately 91 acres of wetlands by filling, and several hundred acres of wetlands through drainage. The Modified Raindriven alternative has these features plus 8 gated structures and tieback levees, resulting in an additional 44 acres of wetlands fill.

The Modified Raindriven plan imposes water use restrictions for WCA3A in order to protect Critical Habitat for the endangered snail kite.

OTHER ANALYSES CONSIDERED

In addition to a thorough analysis of this project by the Park (much of which is incorporated in this document), they identified certain "guidelines" for hydrologic conditions which they feel are related to aquatic productivity and wading bird colony success. According to those criteria, the Modified Raindriven plan performed best with the highest number of positive scores. Overall, the Park expressed a preference for the Modified Raindriven Plan among the currently available alternatives.

The Service also received comments provided in response to an information package sent out to interested parties in November, 1989 (Appendix F). Additionally, several prominent researchers have published observations and recommendations relevant to this study.

A report on the nesting ecology of snail kites in WCA3A was funded by the Corps and SFWMD specifically to investigated potential impacts of this project (Bennetts, Collopy and Beissinger 1988). Among their conclusions were:

> WCA-3A has been the stronghold for the vast majority of the snail kite population in Florida for the past 15 years and has received Federal designation as "critical habitat" for the kite... The alternatives in the GDM with the S-349 structures [Basic Raindriven] would result in lowering the hydroperiod at 3-28 gauge from its present 99% (360 days) to approximately 85-86% (309-314 days). A decline in hydroperiod of this magnitude also is likely to result in shorter dry-down intervals. More frequent dry-outs of WCA-3A will increase the frequency of kite dispersal, which may result in population declines (Beissinger and Takekawa 1983, Beissinger 1986, Takekawa and Beissinger in prep) and shorten the time between droughts for the kite population to recover (due to lag year effect

on food supplies). This would speed up the oscillations of population cycles of the kite, probably resulting in a downward cycling trend (because of the lack of sufficient recovery time from dry-down induced mortality events).

Their report also concluded that reflooding of NESS could expand the breeding habitat of snail kites, but that this only could occur over a prolonged period (10 years). Therefore, hydrologic conditions in WCA3A should be maintained to conserve this endangered species.

This view also was supported by Florida Game and Fish Commission researcher James Rodgers, Jr. (letter in Appendix A). More general comments on the relative suitability of the alternatives were sent by Brian S. Barnett, south Florida Section Leader for the Florida Game and Freshwater Fish Commission (Appendix G). His recommendation was to avoid passing water through WCA3B (as is done in the Modified Raindriven) because that area currently has "excellent everglades wildlife values and good water quality". Moreover, WCA3B is "leaky"; seepage losses are likely to be extensive, resulting in reduced surface flows to NESS. Barnett concurs in the importance of the slough in the southeast corner of WCA3A as a critical habitat for fish and wildlife during drought events, and concludes that the Modified Minimum plan is the best of the action alternatives.

John C. Ogden of the Park sent a letter critiquing the Service's evaluation of impacts to the snail kite. His letter and a response are provided in Appendix G.

Other comments regarding the snail kite were received from Steven R. Beissinger (Appendix G); his population modeling exercise using the Corps' hydrologic data supported the Modified Minimum over the Modified Raindriven alternative.

Frederick and Collopy (1988) described results from investigations on reproductive ecology of wading birds in the Everglades. This study also was conducted to provide information for evaluating the current project. The authors are generally supportive of a rainfall-driven plan, but their results from the two years of the study do not clearly support any of the alternatives. They conclude that drying rate is "the primary factor that should be used to evaluate the effects of the rainfall-driven plan in Shark Slough, with respect to wading bird reproduction". This, in fact, was the key variable in both the Park's wading bird model and the Service's wood stork model. Both indicated that the Modified Minimum Delivery was superior to the rain-driven alternative. Frederick and Collopy point out the need to model and presumably enhance feeding habitat for the birds at the mangrove-sawgrass interface. Other workers (e.g. C. Walters) have suggested that the latter area is so important

that flows should not be diverted through the "leaky" WCA3B, but shunted to the southwest, towards the coastal colony sites.

Kushlan (1987) discussed management of hydrology in the Everglades. He generally supports an approach that reduces impacts from regulatory releases and rediverts flows into NESS, and thus has the structural features of the Modified Raindriven plan. In a letter regarding the current project, however, he rejects the idea that restoring the Water Conservation Areas is necessary or even desirable for improving water deliveries to the Park (Appendix H).

DISCUSSION

Restoration Objectives

According to the results presented in Summary Table 2, the hydrologic restoration objectives are best met by the Modified Raindriven Plan. It ameliorates sudden (regulatory) discharges, widens the flow distribution, has more natural fluctuation in flow, and best restores stages in NESS.

The Modified Raindriven offers more "flexibility" than the other alternatives since water can be discharged from WCA3A both to the south and to the southeast. However, flexibility could be considerably increased by enlarging Structure 333. This would allow flows to be directed into NESS without the necessity of running them through WCA3B, meeting the concerns of the Florida Game and Freshwater Fish Commission and following the suggestion of C. Walters. This routing (via S-333) is currently in use under the experimental deliveries program.

The Modified Minimum reduces the extent of flooding in the "chimney" of the Park by allowing lateral redistribution of flows into NESS, following removal of the L-67 extension. The redirection of flow provides more natural spatial distribution of water, although not as effectively as by the Modified Raindriven.

Both action alternatives fall somewhat short in restoring the extent and quality of short hydroperiod wetlands (Davis et al. 1989). Neither plan significantly refloods the southeastern edge of NESS (see Figures 12 and 13, duration of flooding > 4 cm). In fact, eight and a half square miles of the Eastern Everglades would be permanently "flood protected" within a ring levee. Both action alternatives shorten hydroperiods on the west side of Shark Slough, in line with restoration goals.

The Modified Raindriven shows more uniform hydroperiods in WCA3A, apparently due to backwater effects from water diversion into WCA3B,

cutbacks in water releases during drought, and supplementary deliveries from Lake Okeechobee. This plan best rediverts flows into NESS, increasing the proportion of the time this wetland is flooded by up to 58%. The effect of this flooding must also be reviewed in the context of overall hydropatterns (see wood stork, below).

Another project objective is to reduce impacts from abrupt release of water which occurs under the Base condition. The Park states:

> Under natural, unmanaged conditions, surface water flows were driven almost entirely by upstream rainfall and antecedent hydrologic conditions. In the absence of today's canal and levee systems, the impacts of large rainfall events were attenuated by the slower surface water flow rates through the open marshes. With the current system of upstream canals, levees, and water conservation areas, stormwater is moved rapidly through the system...
>
> Under the Base (BA) and Modified Base (BC) alternatives, flows to the park followed the Minimum Delivery Schedule until the WCA 3A regulation schedule was exceeded. Once this happened the S-12 structures were opened full until water levels in WCA 3A dropped back below the schedule. In addition, all of the flows to Shark Slough are required to pass through the western flow section. This strict adherence to the old regulation schedule and inability to divert excess flows into adjacent areas, produced abrupt increases in deliveries to Shark Slough...
>
> Under the Basic Rain-Driven (MU) and Modified Rain-Driven (MP) alternatives, flows to the park are controlled by upstream rainfall until water levels in WCA 3A enter a series of transition zones defined by the District's Rainfall-Driven Plan. Once into a transition zone, regulatory discharges increase at a rate of 2500 cfs for each foot increase in the stage above the base of the transition zone. In addition, flows through the study area were delivered from WCA 3A directly into WCA 3B and then into Northeast Shark Slough. The implementation of these transition zones and the spreading of flows over a larger area, produced a more gradual rise in the Shark Slough discharge hydrographs and an extended recession period after the peak...

The transition zone feature used in the Modified Raindriven clearly is advantageous, and could be used in other delivery alternatives.

Effects from sudden discharges are reduced under the Modified Minimum by spreading flows across a broader front. However, local effects in the Park would be far more pronounced than under the Modified Raindriven plan.

Biological Objectives

According to outside experts, the analyses by the Park, and our own evaluation, the Modified Minimum provides somewhat better habitat conditions for the species of interest (see Summary Table 2). However, it appears likely that a superior water delivery schedule can be identified through additional modeling, provided the necessary water supplies be available.

Wood stork: The Modified Minimum produced the most favorable extent and timing of flooding on a seasonal basis, according to the wood stork and wading bird analyses. The significant reduction in habitat suitability for the wood stork under the Modified Raindriven may be related to the concentration of flows into NESS, right up to the L-31 levee on the east side. The project does not recover the short hydroperiod marshes on the east side of the Slough (Davis et al. 1989), and the conversion of NESS into a longer hydroperiod wetland may increase forage supplies while reducing their accessibility to wood storks. Presumably, unfavorable drying rates under the Modified Raindriven alternative caused it to perform most poorly according to the Park's modeling.

Snail kite: The effects from both action alternatives on nesting habitat for snail kites are minor. The effect of the Modified Raindriven on drought refugia is small in area, but biologically more significant. It appears likely that additional water supplies will be needed to assure maintenance of some wetland habitat during dry years.

Alligator: While the Modified Raindriven is best at moderating sudden releases, the Park's population model of the alligator does not show corresponding benefit from reduced nest flooding. In fact, nest flooding was lower under the Modified Minimum than under the Modified Raindriven.

Constraints: One hydrologic impact from the modified water delivery will be higher water stages in the L-29 Canal to provide "head" for discharging water into NESS. This will affect a Miccosukee Indian settlement along Tamiami Trail. The project sponsor will relocate or elevate the Indian structures to reduce damage from flooding. This land is owned by the Park and leased to the Tribe. Because of the land ownership, the Miccosukee Tribe is negotiating directly with the SFWMD, and the Bureau of Indian Affairs (Department of Interior) is not involved. The latter agency has not been requested to assist the Tribe, and has no position on the project.

The Modified Raindriven reduces demand on Lake Okeechobee during dry years, and so is best for conservation of water supply. However, the reduced water demand under this alternative comes at the expense of drought refugia for wildlife. Both the Base and Modified Minimum offer about 20 square miles of

wetlands which didn't dry out during even the driest years in the model runs. The Modified Raindriven had complete drying of all cells during one year, which would have been a hardship on a variety of wildlife.

Consideration of a Flow-way: Based on soils analysis and historic accounts, Lake Okeechobee was hydrologically connected with the Everglades in the geologic past (Stone et al. 1989). MacVicar and Johnson (1989) have been developing a hydrologic model for the prehistoric Everglades which incorporates free overflow from the south end of the Lake. Their model is said to depict very long hydroperiods in the southern Everglades, in part due to the damping out of wet and dry season variations as a result of the prolonged flow path and buffering action of the northern wetlands. The presence of water-lily peat deposits in Shark River Slough would tend to confirm this finding (Tropical BioIndustries, Inc.). Drainage and conversion of the northern Everglades for agriculture has made deliveries more peaked, with exaggerated flooding and drying events. This situation might be corrected to a substantial degree through development of a flow-way, from Lake Okeechobee to the southern Everglades. Such a flow-way has been proposed several times in the past; one such proposal is given in Appendix E.

A flow-way could be used to redirect the modern day "overflows" from Lake Okeechobee (regulatory releases) towards the south, sparing the Caloosahatchee and St. Lucie estuaries the salinity and turbidity impacts resulting from excess discharges. Releases percolating through a vegetated flow-way, could be chemically and physically buffered, restoring longer hydroperiods to the southern Everglades. Structures proposed for the current project really might prove their effectiveness when combined with a flow-way. The structures passing water through WCA3B, or an enlarged S-333, could direct flows into the main stem of Shark River Slough; the timing of such regulatory releases would likely be in accord with a Raindriven schedule, since they would be initiated by rainfall events. As noted by the Park, none of the current alternatives offer the significant environmental enhancements expected under a restoration project. In part, this is due to the imposition of a current level of water supply and demand, and fairly inflexible deliveries based on regulatory schedules upstream. Also, the rainfall formula used may deliver too little water, with too great seasonal extremes. A flow-way might offer a means to correct these problems.

Moreover, the increased volumes of water conveyed by a flow-way could alleviate concerns about impacts to endangered species from drying out of WCA3A (see Appendix A), would provide more water to benefit Florida Bay Fisheries (Smith et al. 1989), and enhance coastal feeding areas for wading birds (Frederick and Collopy 1988).

EFFECTS ON ENDANGERED SPECIES

On May 19, 1988 the Service advised the Corps of the potential for the project to affect one or more of five endangered species (the snail kite, Florida panther, Cape Sable seaside sparrow, wood stork, and American crocodile), and reinitiated consultation on the snail kite under Section 7 of the Endangered Species Act.

On November 21, 1989, the Corps advised that the project may affect the wood stork and snail kite. The Service's Biological Opinion (Appendix A) was finalized on February 13, 1990 and concluded that the Basic Raindriven alternative would jeopardize the continued existence of the snail kite. It found that the Modified Raindriven alternative would not jeopardize the kite, but would incidentally take kites and thus required the imposition of Terms and Conditions to limit this take. The Modified Minimum delivery would actually benefit both endangered species.

The Corps determined that the project would not be likely to adversely affect the Cape Sable seaside sparrow, the Florida Panther, or the American Crocodile. Based on our review of information contained in the Corps' Biological Assessment, the Service concurs with that determination. Although this concurrence does not constitute a Biological Opinion described under Section 7 of the Endangered Species Act, it does fulfill the requirements of the Act and no further action is required.

SUMMARY AND CONCLUSIONS

The Modified Water Deliveries Project objectives are to restore and enhance ecological characteristics of Everglades National Park and Northeast Shark River Slough by improving deliveries of surface waters.

The conclusions reached in this Coordination Act report rely on a comprehensive review of information provided by hydrological and ecological monitoring and research, expert opinion, and modeling of anticipated hydrological and biological performance of the alternatives. Modeling efforts included use of the Corps of Engineers' Surface Water Model, habitat suitability models of the snail kite, wood stork, and alligator developed by the Fish and Wildlife Service (Service), and wading bird and alligator population models used by Everglades National Park (Park). The Service's habitat models and the validation procedures are appended.

The Service reviewed four water delivery alternatives. These included a no action alternative (Base), a Modified Minimum alternative (using the guaranteed minimum delivery schedule and few new structures), and two raindriven alternatives. Both raindriven alternatives use a formula based on precipitation to schedule deliveries through 8 new structures. One, the Basic Raindriven, uses current water supplies and demands. The second the Modified Raindriven, uses supplementary water and restrictions on demand to conserve water supplies in WCA3A. The three action alternatives were developed as initial steps towards the stated restoration goals for the Shark Slough Basin.

All alternatives were reviewed for their effect on Federally listed endangered and threatened species (Appendix A). The Service concluded that the Basic Raindriven alternative jeopardized the continued existence of the snail kite and adversely modified its critical habitat. The Basic Raindriven alternative, therefore, was eliminated from further consideration.

The two remaining action alternatives were compared to the Base (no-action) condition. The Modified Minimum delivery was found to benefit both the snail kite and the wood stork, and so best complies with Section 7(a)(1) of the Endangered Species Act. The Modified Raindriven alternative would not jeopardize either listed species, but might incidentally take snail kites. Several Reasonable and Prudent Measures were devised to protect the kite, should this alternative be implemented.

The Modified Minimum was the best of the action alternatives according to our biological criteria, provides the best conditions for the Miccosukee Indians to utilize their airboats within southern WCA3A, and requires less filling and

construction in wetlands than the Modified Raindriven (approximately 91 acres compared to 135 for the latter). However, the Modified Raindriven most closely approximated the Park's restoration goals, and appears to be most conservative of water supplies in Lake Okeechobee during dry years.

Concerns about the incorporation of WCA3B into the delivery system (as under the Modified Raindriven) include loss of water through seepage, alteration and elimination of existing high quality Everglades habitat, effect on drought refugia in WCA3A, conflict with existing management by the Florida Game and Fresh Water Fish Commission, and conflict with Service's recovery goals for the endangered snail kite. However, the National Park Service has concluded that there are major ecological benefits to WCA3B from raindriven water deliveries.

Recommendations

Among the Fish and Wildlife Coordination Act agencies, the National Marine Fisheries Service unequivocally supports the Modified Raindriven schedule (Appendices L and M). The Florida Game and Fresh Water Fish Commission recommends that the Modified Minimum delivery be adopted (Appendices K and N). This is because of concern over diverting the poorer quality water from the L-67 canal across Area 3B, since this action would degrade some of the most pristine Everglades habitat remaining. However, once the nutrient reduction goals of the Everglades SWIM Plan are reached would discharge across Area 3B be acceptable to the Game Commission. The Commission also expressed concern over elimination of fishermen access to L-67 canals by the new structures (Appendix P).

Based on the above information, and input from the Park, Corps, South Florida Water Management District, and Florida Game and Fresh Water Fish Commission, the Fish and Wildlife Service recommends:

1) Structures should be built to allow redistribution of flows across the original width of Shark River Slough. This may be accomplished as called for under the Modified Raindriven alternative, by installing 8 structures to pass water through WCA3B. Although not one of the project alternatives, the Service recommends enlarging S-333 to deliver flows directly from WCA3A through the L-29 canal into Northeast Shark River Slough, thus providing additional operational flexibility.

2) The proposed structures will provide the means of initiating the restoration process in the southern Everglades; the Service recommends that all of the proposed structures be built. It is also apparent that a raindriven water schedule will best meet the goals of the project. The operational water delivery

schedule, therefore, will be based on refinement of the current rainfall formula. This refinement must consider results from modeling, iterative testing, and monitoring. Thus, the Fish and Wildlife Service and National Park Service are committed to developing an appropriate raindriven scenario that improves the timing and volume of water deliveries to Everglades National Park.

3) Further planning and modeling should be undertaken by the Corps and the South Florida Water Management District in order to resolve potential conflicts over competition for water. It is apparent that new wellfields, and even the proposed nutrient removal areas in the Everglades SWIM Plan, are likely to increase demands beyond those modelled for 1990.

4) The Park Service is currently monitoring key indicator and endangered species in the Park and NESS, and has proposed to continue a long-term monitoring program to measure responses by these species to all future operational schedules. The Service recommends implementation of supplemental monitoring efforts to cover the other portions of the southern Everglades and other ecological effects. It should include the following elements:

a) An ecological succession model should be developed for projecting vegetative changes in response to water stages, durations of flooding, and water quality, and should be validated using field data from the southern Everglades.

b) Monitoring of wood stork colonies and associated habitat factors should be undertaken in order to verify appraisals made using the habitat suitability model. Monitoring also should continue for the snail kite to verify the conclusions from that analysis. This should include at least the winter population counts (if the Modified Minimum schedule is used), or the more extensive surveys required by the Terms and Conditions of the Biological Opinion (Appendix A) if the Modified Raindriven schedule is used.

c) These data should be entered into a geographic information system, and the database be maintained for future planning and management decisions in the southern Everglades.

ADDITIONAL RECOMMENDATIONS

The Service offers the following recommendations concerning features and issues which were not dealt with in the current project alternatives but may enhance the success of the water delivery system.

1) In order to have the option of delivering water directly into Northeast Shark Slough, thus bypassing WCA3B, we recommend enlarging Structure 333 in the L-29 canal. This could satisfy the State of Florida's concerns over habitat changes in WCA3B, conserve water supplies, and add to flexibility in routing water during droughts, or add conveyance during high flow periods.

2) We are convinced that structures included under the Modified Raindriven will increase operational flexibility, but it does not appear that the present water supply (both volume and timing) would take full advantage of the proposed system. This situation, until rectified, will hamper efforts to restore the Everglades. In view of rapidly increasing water demands in south Florida, it is essential to identify and allocate adequate water supplies for the remaining Everglades. During this analysis the water needs of the northern Everglades (Arthur A. Marshall Loxahatchee National Wildlife Refuge, WCA2A and WCA2B) also should be considered. Therefore, the Corps of Engineers should reinitiate the Central and Southern Florida Water Supply Study for such planning purposes.

3) Restoration of a portion of the historic flow-way from Lake Okeechobee to the southern Everglades could help meet the project objectives. A vegetated flow-way could convey increased volumes, remove nutrients, and smooth transitions in timing (see Appendix E). The rainfall-driven delivery concept calls for highest volumes in wet years, when regulatory releases would be available from the Lake. The conveyance of regulatory releases to the south also would spare both the Caloosahatchee and St. Lucie estuaries impacts from excessive fresh water discharges.

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Table 1. VALIDATION OF ALLIGATOR HSI MODEL, VERSION 1.2 a

X	Y	DFL550	DFLDEEP	FRDRY	NO.PNDSWT	HSI
11	18	0.14	0.00	0.22	0	0.35
12	18	0.08	0.00	0.15	0	0.31
14	18	0.05	0.00	0.42	0	0.37
15	18	0.04	0.00	0.31	0	0.34
16	18	0.14	0.00	0.33	1	0.38
17	18	0.79	0.01	1.13	0	0.64
18	18	0.86	0.04	1.83	1	0.72
19	18	0.82	0.11	1.88	1	0.75
20	18	0.73	0.12	1.55	1	0.74
21	18	0.77	0.11	1.87	0	0.75
22	18	0.65	0.02	13.92	0	0.71
23	18	0.91	0.02	1.86	0	0.71
11	16	0.01	0.00	0.56	0	0.37
12	16	0.45	0.04	0.61	1	0.55
13	16	0.15	0.01	0.27	1	0.40
15	16	0.16	0.00	0.30	2	0.38
16	16	0.64	0.03	1.56	2	0.68
17	16	0.75	0.04	1.06	0	0.65
18	16	0.74	0.10	1.77	3	0.73
19	16	0.73	0.11	1.37	0	0.72
20	16	0.42	0.04	0.89	0	0.58
21	16	0.11	0.00	0.36	1	0.38
22	16	0.07	0.00	0.25	0	0.34
23	16	0.01	0.00	0.13	0	0.27
12	14	0.01	0.00	0.67	0	0.38
13	14	0.42	0.20	1.06	0	0.67
14	14	0.61	0.05	1.36	1	0.67
15	14	0.58	0.24	1.86	0	0.76
16	14	0.71	0.19	1.87	3	0.77
17	14	0.76	0.13	1.85	2	0.76
18	14	0.76	0.10	1.57	4	0.74
19	14	0.38	0.03	0.76	1	0.56
20	14	0.20	0.01	0.36	1	0.42
21	14	0.02	0.00	0.21	0	0.30
22	14	0.02	0.00	0.21	0	0.30
23	14	0.40	0.00	0.36	0	0.45

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Table 2. Summary of Attributes of Water Delivery Alternatives

OBJECTIVES - ATTRIBUTES	CHARACTERISTICS OF THE ALTERNATIVES		
	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVEN
RESTORATION OBJECTIVES			
1) Reduce effects from regulatory releases:	existing	slight dissipation	smoother transition, dissipation
2) Wider flow distribution:	western	spreads towards NESS	discharge into NESS, approaches "natural"
3) Volume and timing fluctuate naturally:	schedule plus regulatory releases	schedule plus regulatory releases	rainfall formula plus reg. releases
4) Restore water stages in the Park and NESS:	too wet in western Shark Slough	improvement in NESS	best for NESS and western S. Slough
BIOLOGICAL OBJECTIVES			
Protect and recover the wood stork and other wading birds			
5) Extent of flooding > 4 cm deep:			
WCA3A (111 cells)	83	84	86
WCA3B (36 cells)	69	71	72
NESS (55 cells)	38	45	51
ENP (175 cells)	49	48	47
6) Results from wood stork habitat model (based on proportion of range drying over 4 months)			
habitat suitability:	0.33	0.38	0.26#
	(# = significantly lower than Base)		
7) Results from Park wading bird colony modeling			
% nesting success:	47	48	40

Table 2. continued

OBJECTIVES - ATTRIBUTES	CHARACTERISTICS OF THE ALTERNATIVES		
	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVEN
Protect and recover the snail kite and other "slough species"			
8) Results from snail kite habitat model (based on value for nesting):			
habitat suitability:	0.197	0.195	0.245
	(no significant differences)		
9) Drought refugia (sq. miles):			
area flooded 6<>14 yrs:	32	20	28
area flooded all 14 yrs:	16	28	0
Effects on the alligator			
10) Results from alligator habitat model			
habitat suitability:	0.632	0.641#	0.639
	(no significant differences)		
11) Results from Park alligator modeling			
Average population:	116300	124600	125250
% Signif. nest flooding:	19	28	32
Effects on WCA3A Indian airboat use: (requires stage => 7.4' at structure 12B)			
12) number of months too dry over 14 year period of record:	16	11	14

Table 2. continued

OBJECTIVES - ATTRIBUTES	CHARACTERISTICS OF THE ALTERNATIVES		
	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVEN
Effects on Lake Okeechobee stages (for 14 years)			
13) Number of months stage more than .1' lower than base:		0	51
number of months stage more than .1' above base:		0	11
Other impacts of operation and construction:			
14) Complexity: new operable structures needed;	0	2 seepage pumps, levees	2 seepage pumps, levees, 8 gated structures
Wetland impacts:	0 0	fill 91 acres, additional acres drained	fill 135 acres, additional acres drained
Water requirements:	existing	existing	reduced in dry years

Table 3. Seasonal flow percentages for the two Shark Slough flow sections (S12 - western flow section and NES - eastern flow section).

YEAR	SEASON	BAS12%	BANES%	BCS12%	BCNES%	MUS12%	MUNES%	MPS12%	MPNES%
1969	DRY	95.5	4.5	96.1	3.9	42.7	57.3	42.3	57.7
1969	WET	100.0	0.0	100.0	0.0	54.3	45.7	64.3	35.7
1970	DRY	98.4	1.6	98.7	1.3	46.0	54.0	61.1	38.9
1970	WET	99.8	0.2	99.9	0.1	49.0	51.0	52.6	47.4
1971	DRY	77.1	22.9	79.9	20.1	9.4	90.6	11.8	88.2
1971	WET	93.0	7.0	93.8	6.2	44.9	55.1	43.9	56.1
1972	DRY	90.2	9.8	93.1	6.9	44.0	56.0	43.8	56.2
1972	WET	99.9	0.1	99.9	0.1	50.5	49.5	47.2	52.8
1973	DRY	89.9	10.1	91.7	8.3	36.1	63.9	43.1	56.9
1973	WET	98.7	1.3	99.0	1.0	52.9	47.1	46.1	53.9
1974	DRY	81.1	18.9	81.9	18.1	29.7	70.3	28.4	71.6
1974	WET	96.7	3.3	97.3	2.7	47.0	53.0	45.6	54.4
1975	DRY	79.9	20.1	80.9	19.1	34.2	65.8	31.7	68.3
1975	WET	99.5	0.5	99.5	0.5	47.3	52.7	45.2	54.8
1976	DRY	77.2	22.8	79.5	20.5	29.2	70.8	32.3	67.7
1976	WET	99.8	0.2	99.8	0.2	50.3	49.7	47.8	52.2
1977	DRY	83.7	16.3	84.2	15.8	36.6	63.4	37.8	62.2
1977	WET	98.0	2.0	98.6	1.4	44.5	55.5	44.3	55.7
1978	DRY	96.9	3.1	98.6	1.4	44.7	55.3	44.6	55.4
1978	WET	99.9	0.1	100.0	0.0	46.4	53.6	45.2	54.8
1979	DRY	85.5	14.5	86.8	13.2	41.6	58.4	41.9	58.1
1979	WET	99.9	0.1	99.9	0.1	44.9	55.1	45.0	55.0
1980	DRY	96.0	4.0	98.6	1.4	44.3	55.7	44.1	55.9
1980	WET	99.0	1.0	99.2	0.8	44.5	55.5	44.6	55.4
1981	DRY	89.8	10.2	92.9	7.1	30.5	69.5	32.4	67.6
1981	WET	96.2	3.8	96.0	4.0	54.2	45.8	46.1	53.9
1982	DRY	80.3	19.7	83.9	16.1	28.5	71.5	37.9	62.1
1982	WET	99.9	0.1	99.9	0.1	51.3	48.7	47.4	52.6
DRY MEAN		87.3	12.8	89.1	10.9	35.5	64.5	38.1	61.9
DRY ST. DEV.		7.6	7.6	7.4	7.4	9.9	9.9	11.1	11.1
WET MEAN		98.6	1.4	98.8	1.2	48.7	51.3	47.5	52.5
WET ST. DEV.		2.0	2.0	1.9	1.9	3.6	3.6	5.3	5.3

Table 4. Seasonal flow totals for the two Shark Slough flow sections under actual conditions and the four proposed alternatives.

YEAR	SEASON	BAS12	BANES	BASUM	BCS12	BCNES	BCSUM	MUS12	MUNES	MUSUM	MPS12	MPNES	MPSUM	ACTS12	ACTNES	ACTSUM
1969	DRY	148393	6942	155335	150868	6198	157066	54398	72943	127341	53959	73655	127614	316925	15349	332274
1969	WET	1174491	0	1174491	1181206	0	1181206	570105	479303	1049408	791469	440036	1231505	1229143	38212	1267355
1970	DRY	750149	12394	762543	757299	9916	767215	365417	429736	795153	709894	451779	1161673	932787	29460	962247
1970	WET	580894	992	581886	588218	496	588714	355050	369046	724096	406396	366853	773249	487691	36858	524549
1971	DRY	67697	20078	87775	67915	17104	85019	1975	19138	21113	3199	24002	27201	78701	2837	81538
1971	WET	175624	13137	188761	176216	11650	187866	72348	88904	161252	72247	92259	164506	162007	11115	173122
1972	DRY	70550	7686	78236	70549	5206	75755	71693	91186	162879	71693	92144	163837	85404	8313	93717
1972	WET	315919	248	316167	343721	248	343969	215350	210682	426032	198209	221509	419718	227349	28819	256168
1973	DRY	68056	7685	75741	68221	6197	74418	30350	53624	83974	39174	51695	90869	86290	4558	90848
1973	WET	239899	3222	243121	240541	2478	243019	157016	139815	296831	149385	174867	324252	190326	28018	218344
1974	DRY	68136	15864	84000	68327	15121	83448	14303	33864	48167	14303	35991	50294	72772	2301	75073
1974	WET	188113	6445	194558	188346	5205	193551	110499	124564	235063	109517	130475	239992	388029	13858	401887
1975	DRY	67855	17104	84959	68145	16113	84258	21258	40955	62213	22354	48070	70424	86576	4997	91573
1975	WET	189411	992	190403	189410	992	190402	116184	129482	245666	114260	138760	253020	195442	23356	218798
1976	DRY	70327	20822	91149	70385	18096	88481	13532	32797	46329	17121	35898	53019	73546	6243	79789
1976	WET	341448	744	342192	346678	744	347422	229278	226480	455758	233116	254944	488060	274703	47027	321730
1977	DRY	69969	13634	83603	70061	13139	83200	33247	57479	90726	35529	58584	94113	75923	7898	83821
1977	WET	143109	2975	146084	144321	1983	146304	60662	75735	136397	60723	76232	136955	198705	17614	216319
1978	DRY	70225	2231	72456	70228	992	71220	57327	70918	128245	57327	71168	128495	109416	13469	122885
1978	WET	244388	248	244636	257405	0	257405	167905	193989	361894	181373	220214	401587	444489	54378	498867
1979	DRY	70229	11898	82127	70229	10658	80887	48104	67517	115621	48104	66774	114878	119975	26114	146089
1979	WET	189365	248	189613	189410	248	189658	91541	112127	203668	107288	130934	238222	271425	17966	289391
1980	DRY	148865	6197	155062	187339	2727	190066	113549	142784	256333	123983	157020	281003	333900	25065	358965
1980	WET	176785	1736	178521	179677	1488	181165	64120	79923	144043	77745	96538	174283	226361	15954	242315
1981	DRY	67774	7685	75459	67978	5207	73185	14583	33193	47776	17387	36309	53696	75116	176	75292
1981	WET	232859	9172	242031	233594	9668	243262	139772	118296	258068	146468	171327	317795	193346	17928	211274
1982	DRY	69888	17105	86993	69941	13385	83326	25511	63966	89477	35329	57862	93191	67997	5871	73868
1982	WET	412986	248	413234	415492	248	415740	260628	247849	508477	246737	273799	520536	979931	61686	1041617
DRY MEAN		129151	11952	141103	132678	10004	142682	61803	86436	148239	89240	90068	179308	179666	10904	190570
DRY ST.D.		181024	5707	180873	183493	5618	183058	92146	103525	195574	181200	109147	289680	233968	9586	241057
WET MEAN		328949	2886	331836	333874	2532	336406	186461	185443	371904	206781	199196	405977	390639	29485	420124
WET ST.D.		270343	3987	268996	271984	3729	270757	138869	116898	254963	191281	106418	292780	322281	15949	332146

Table 5. Seasonal surface water depth characteristics for the Northeast Shark Slough Basin.,

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	59.43	42.86	44.57	44.00	25.71	22.86	20.00	17.71	13.14	27.43	32.00	29.72	1.71	6.86	3.43	8.57
69 WET	17.14	10.48	13.33	19.52	11.91	10.48	10.00	4.29	10.95	5.24	1.91	1.43	60.00	73.81	74.76	74.76
70 WET	37.62	28.09	23.81	23.33	15.72	2.38	2.38	2.86	29.05	16.67	8.09	6.19	17.62	52.86	65.72	67.62
71 DRY	81.90	70.00	75.72	75.72	11.43	14.29	15.72	14.29	5.72	14.76	8.10	9.52	0.95	0.95	0.48	0.48
71 WET	42.38	34.76	34.76	33.81	25.24	24.29	29.53	20.47	26.67	26.67	23.33	25.71	5.72	14.29	12.38	20.00
72 DRY	67.62	46.67	41.43	41.43	21.91	31.91	20.48	16.67	8.57	19.05	27.62	28.57	1.91	2.38	10.48	13.34
72 WET	40.95	30.00	27.14	27.14	24.76	9.05	2.86	2.86	21.43	19.05	19.53	15.24	12.86	41.91	50.48	54.76
73 DRY	78.57	62.38	61.91	58.10	13.81	17.62	16.19	17.62	6.19	18.10	20.95	21.90	1.43	1.91	0.95	2.38
73 WET	46.19	36.66	34.29	32.38	22.38	19.53	12.86	11.91	21.91	21.91	21.91	15.72	9.52	21.91	30.95	40.00
74 DRY	84.76	70.00	71.91	70.95	10.48	13.81	15.72	14.28	3.33	14.76	11.43	11.43	1.43	1.43	0.95	3.33
74 WET	42.38	32.86	32.86	32.38	24.76	23.81	15.71	14.28	23.81	25.24	21.90	17.62	9.05	18.09	29.53	35.72
75 DRY	78.57	62.86	66.19	62.86	13.81	20.00	18.57	18.57	6.19	14.76	13.33	14.29	1.43	2.38	1.91	4.29
75 WET	42.38	32.38	30.95	30.47	24.29	22.38	17.62	9.52	23.81	30.47	25.72	25.24	9.53	14.76	25.72	34.76
76 DRY	73.33	52.38	58.57	55.24	19.05	27.14	29.05	27.62	5.71	19.52	12.38	16.19	1.91	0.95	0.00	0.95
76 WET	32.38	24.76	24.76	25.24	15.72	10.00	4.29	2.38	25.71	22.86	18.57	10.95	26.19	42.38	52.38	61.43
77 DRY	69.05	59.05	55.71	54.29	21.43	22.86	20.95	18.57	8.10	14.76	20.00	20.95	1.43	3.33	3.33	6.19
77 WET	55.24	41.43	37.14	34.28	26.19	27.14	24.29	18.10	14.76	23.81	30.00	29.52	3.81	7.62	8.57	18.10
78 DRY	72.86	43.81	37.62	39.52	18.57	31.90	27.14	19.52	7.62	22.86	32.86	35.24	0.95	1.43	2.38	5.72
78 WET	36.67	28.57	26.67	26.19	20.00	16.67	5.24	4.29	29.52	22.38	20.48	15.24	13.81	32.38	47.62	54.29
79 DRY	61.90	46.19	44.76	41.43	28.57	31.90	23.33	23.33	8.10	18.57	28.57	25.24	1.43	3.33	3.33	10.00
79 WET	40.48	33.33	29.05	30.00	30.95	24.76	12.86	8.57	19.05	19.05	29.05	24.29	9.53	22.86	29.05	37.14
80 DRY	50.00	34.29	30.47	30.47	30.00	18.10	11.43	7.14	14.76	35.24	27.62	24.29	5.24	12.38	30.48	38.10
80 WET	44.76	31.43	31.91	30.48	30.95	21.43	16.67	11.43	17.14	36.19	34.29	27.14	7.14	10.95	17.14	30.95
81 DRY	83.33	62.86	68.10	66.19	10.48	18.10	23.81	22.86	5.24	17.62	8.10	10.48	0.95	1.43	0.00	0.48
81 WET	51.43	46.67	47.62	46.19	14.29	7.62	6.67	6.19	14.76	14.76	13.34	9.05	19.52	30.95	32.38	38.57
82 DRY	66.19	44.76	44.29	39.53	22.86	32.86	28.57	25.24	9.05	20.48	21.91	28.57	1.91	1.90	5.24	6.67
82 WET	35.72	27.62	26.19	25.72	14.76	6.19	2.38	2.86	27.62	20.00	13.81	11.43	21.91	46.19	57.62	60.00
WET MN.	40.41	31.36	30.03	29.80	21.57	16.12	11.67	8.57	21.87	21.74	20.14	16.77	16.16	30.78	38.16	44.86
WET S. D.	9.01	8.30	7.81	6.35	6.22	8.23	8.47	5.97	5.81	7.29	2.33	8.57	14.17	18.81	20.19	17.41
WET MD.	41.67	31.91	30.00	30.24	23.34	18.10	11.43	7.38	22.86	22.15	21.19	15.48	11.20	26.91	31.67	39.29
DRY MN.	69.52	51.84	51.93	50.29	19.02	22.08	19.46	17.56	8.42	19.48	19.50	19.91	3.05	6.61	9.12	12.25
DRY S.D.	12.05	13.05	15.73	15.40	6.47	8.25	7.34	6.73	3.77	5.83	9.20	9.43	4.99	13.39	17.85	19.39
DRY MD.	70.96	49.53	50.24	49.15	18.81	21.43	20.24	18.14	8.00	18.34	20.48	21.43	1.43	2.15	2.86	5.96

Table 6. Surface water hydroperiod characteristics for the Northeast Shark Slough Basin

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	11.43	2.86	5.71	14.29
	1-3	8.57	11.43	11.43	5.71
	4-6	11.42	8.58	5.71	2.86
	7-9	14.28	5.72	2.86	0.00
	10-12	54.29	71.43	74.29	77.15
70-71	0	34.29	22.86	17.14	20.00
	1-3	2.86	5.71	8.57	2.86
	4-6	11.43	2.86	2.86	5.71
	7-9	31.43	22.85	40.00	40.00
	10-12	20.00	45.71	31.43	31.43
71-72	0	37.14	28.57	28.57	28.57
	1-3	5.71	2.86	2.86	2.86
	4-6	8.57	5.71	2.86	5.71
	7-9	34.29	19.99	20.00	17.14
	10-12	14.29	42.86	45.71	45.72
72-73	0	37.14	37.14	25.71	25.71
	1-3	2.86	2.86	2.86	2.86
	4-6	5.72	5.72	0.00	0.00
	7-9	28.57	28.57	17.14	17.14
	10-12	25.72	25.72	54.29	54.29
73-74	0	31.43	22.86	25.71	22.86
	1-3	11.43	5.72	2.86	5.71
	4-6	28.57	14.28	5.72	11.42
	7-9	17.14	48.58	62.86	57.14
	10-12	11.43	8.57	2.86	2.86
74-75	0	34.29	28.57	28.57	28.57
	1-3	5.72	2.86	2.86	0.00
	4-6	14.28	5.71	2.86	8.57
	7-9	34.29	34.28	45.72	37.14
	10-12	11.43	28.57	20.00	25.71
75-76	0	37.14	28.57	28.57	28.57
	1-3	2.86	2.86	2.86	0.00
	4-6	25.72	5.71	8.57	14.29
	7-9	20.00	25.71	42.86	28.57
	10-12	14.28	37.15	17.15	28.56
76-77	0	20.00	17.14	17.14	20.00
	1-3	14.28	11.43	11.43	8.57
	4-6	11.43	2.86	2.86	2.86
	7-9	14.28	20.00	20.00	20.00
	10-12	40.00	48.57	48.57	48.57
77-78	0	40.00	28.57	31.43	28.57
	1-3	17.14	5.72	2.86	5.72
	4-6	11.43	11.43	2.86	5.72
	7-9	2.86	8.57	8.57	2.86
	10-12	28.57	45.71	54.29	57.15
78-79	0	28.57	22.86	22.86	22.86
	1-3	8.57	8.57	5.71	5.72
	4-6	11.43	0.00	0.00	2.86
	7-9	22.86	14.29	11.43	8.57
	10-12	28.57	54.29	60.01	60.00
79-80	0	22.86	17.14	20.00	25.71
	1-3	17.15	14.29	8.57	2.86
	4-6	5.72	0.00	2.86	2.86
	7-9	8.57	11.43	2.86	2.86
	10-12	45.71	57.15	65.72	65.71
80-81	0	37.14	22.86	22.86	25.71
	1-3	5.72	8.57	8.57	2.86
	4-6	17.15	2.86	2.86	8.57
	7-9	17.15	8.58	20.00	14.29
	10-12	22.86	57.14	45.71	48.57
81-82	0	22.86	14.29	20.00	20.00
	1-3	22.86	17.14	8.57	8.57
	4-6	28.58	17.14	20.00	14.28
	7-9	5.72	34.28	37.13	34.28
	10-12	20.00	17.14	14.29	22.86

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	30.33	22.64	22.64	23.96
MEDIAN	0	34.29	22.86	22.86	25.71
ST. D.	0	8.61	8.53	6.85	4.45
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	9.67	7.69	6.16	4.18
MEDIAN	1-3	8.57	5.72	5.71	2.86
ST. D.	1-3	6.45	4.72	3.47	2.76
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	14.73	6.37	4.62	4.09
MEDIAN	4-6	11.43	5.71	2.86	0.00
ST. D.	4-6	7.99	5.24	5.16	5.47
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	19.34	21.76	25.50	21.54
MEDIAN	7-9	17.15	20.00	20.00	17.14
ST. D.	7-9	10.51	12.48	18.53	17.05
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	25.93	41.54	41.10	43.74
MEDIAN	10-12	22.86	45.71	45.71	48.57
ST. D.	10-12	13.48	17.68	21.99	20.45

Table 7. Seasonal surface water depth characteristics for the western/central Shark Slough Basin.

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	36.86	27.71	40.86	38.29	34.86	36.57	36.29	38.86	24.00	26.57	20.86	20.57	4.29	9.14	2.00	2.29
69 WET	0.00	0.00	0.24	0.00	5.48	6.67	6.91	5.24	6.90	6.43	6.67	6.43	87.62	86.91	86.19	88.33
70 DRY	6.67	7.62	7.86	3.81	10.00	13.81	11.67	8.57	22.38	24.29	19.76	13.10	60.95	54.28	60.71	74.53
70 WET	6.90	8.09	5.24	3.34	10.95	11.91	10.71	11.67	21.43	22.62	20.00	16.67	60.71	57.38	64.05	68.34
71 DRY	54.05	57.86	63.10	62.86	21.91	22.38	20.48	20.72	16.43	12.38	9.29	9.29	7.62	7.38	7.14	7.14
71 WET	26.19	30.72	32.38	31.67	30.71	29.53	33.57	30.95	25.72	24.53	24.29	24.05	17.38	15.24	9.76	13.33
72 DRY	25.71	30.00	31.91	29.52	37.62	36.67	38.57	36.19	23.33	22.86	20.72	23.81	13.33	10.48	8.81	10.48
72 WET	10.72	12.38	9.76	9.05	17.38	16.90	14.29	14.29	29.76	32.38	28.81	26.91	42.14	38.33	47.15	49.76
73 DRY	41.66	45.00	49.52	46.91	25.95	25.48	28.33	29.29	20.95	18.57	13.34	14.52	11.43	10.95	8.81	9.29
73 WET	15.72	18.33	18.57	17.86	28.81	28.81	26.90	24.76	27.86	28.10	27.38	24.52	27.62	24.76	27.14	32.86
74 DRY	54.76	57.86	61.19	59.53	20.00	20.95	21.91	22.14	16.67	13.10	9.76	10.72	8.57	8.10	7.14	7.62
74 WET	18.10	21.19	21.19	19.76	29.29	30.00	29.53	27.62	26.43	29.53	27.86	27.38	26.19	19.29	21.43	25.24
75 DRY	43.34	47.14	54.52	52.62	27.62	28.33	26.67	26.91	19.29	15.95	11.43	12.62	9.76	8.57	7.38	7.85
75 WET	14.53	17.62	16.67	15.72	28.81	28.57	27.38	24.52	28.57	30.00	31.90	31.19	28.09	23.81	24.04	28.57
76 DRY	32.62	40.95	49.52	48.33	33.81	33.57	32.38	31.91	25.24	18.33	12.14	13.10	8.33	7.14	5.95	6.67
76 WET	6.91	8.34	7.62	6.67	16.67	17.86	16.19	14.29	29.52	29.76	26.67	24.29	46.91	44.04	49.53	54.76
77 DRY	43.81	45.72	48.81	47.14	25.95	26.43	25.95	25.24	18.81	17.62	15.95	17.14	11.43	10.24	9.28	10.48
77 WET	24.52	29.52	29.53	26.43	32.14	34.52	37.62	35.00	30.00	23.81	24.52	28.33	13.33	12.14	8.33	10.24
78 DRY	22.86	26.67	26.19	24.05	34.52	36.67	44.76	39.52	27.86	22.14	22.86	24.76	14.76	14.52	6.19	11.67
78 WET	8.81	11.20	9.29	8.33	21.91	22.62	17.86	15.48	31.19	31.43	30.00	27.14	38.10	34.76	42.86	49.05
79 DRY	29.05	32.62	35.00	33.57	34.29	34.28	33.10	32.86	23.81	21.43	21.19	22.62	12.85	11.67	10.71	10.95
79 WET	17.62	20.48	17.39	15.48	29.05	28.81	24.05	22.62	24.52	26.19	34.05	31.91	28.81	24.52	24.52	30.00
80 DRY	17.38	16.43	16.67	15.24	30.71	25.47	23.57	20.95	34.53	37.14	37.38	35.00	17.38	20.95	22.38	28.81
80 WET	15.96	18.10	17.62	15.24	24.05	25.95	27.86	22.86	34.05	33.33	30.71	34.05	25.95	22.62	23.80	27.86
81 DRY	43.81	47.86	61.19	58.33	24.29	25.24	27.14	25.00	20.72	17.14	7.38	11.19	11.19	9.76	4.29	5.48
81 WET	31.43	33.57	35.24	33.57	15.24	16.19	14.29	13.10	19.53	20.24	21.19	20.00	33.81	30.00	29.29	33.34
82 DRY	22.62	27.62	33.81	29.29	38.81	41.43	38.57	39.76	26.43	20.72	17.14	18.81	12.14	10.24	10.48	12.14
82 WET	7.38	9.05	8.10	8.09	14.29	15.71	14.29	11.67	27.14	29.29	26.19	23.81	51.19	45.95	51.43	56.43
WET MN.	14.63	17.04	16.35	15.09	21.77	22.43	21.53	19.58	25.90	26.26	25.73	24.76	37.70	34.27	36.39	40.58
WET S.D.	8.65	9.66	10.52	10.16	8.45	8.23	9.23	8.54	6.65	6.88	6.73	6.99	19.36	19.77	21.68	21.64
WET MD.	15.13	17.86	17.03	15.36	22.98	24.29	20.96	19.05	27.50	28.70	27.03	25.72	31.31	27.38	28.22	33.10
DRY MN.	33.94	36.50	41.44	39.25	28.60	29.09	29.24	28.42	22.89	20.59	17.09	17.66	14.57	13.82	12.23	14.67
DRY S.D.	14.01	14.88	17.03	17.55	7.95	7.66	8.70	8.89	4.80	6.24	7.73	7.13	13.74	12.16	14.70	18.25
DRY MD.	34.74	36.79	44.84	42.60	29.17	27.38	27.74	28.10	22.86	19.65	16.55	15.83	11.43	10.24	8.10	9.89

Table 8. Surface water hydroperiod characteristics for western/central Shark Slough Basin

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	1.43	2.86	0.00
	7-9	8.57	8.57	5.72	5.72
	10-12	91.42	90.00	91.43	94.29
70-71	0	2.86	7.14	2.86	0.00
	1-3	4.29	0.00	2.86	2.86
	4-6	4.29	5.72	5.72	5.72
	7-9	20.00	24.29	44.29	47.14
	10-12	68.58	62.86	44.29	44.29
71-72	0	10.00	11.43	11.43	11.43
	1-3	5.72	5.72	8.58	7.15
	4-6	1.43	5.72	5.72	5.72
	7-9	41.42	40.00	38.57	38.57
	10-12	41.43	37.15	35.72	37.15
72-73	0	8.57	10.00	8.57	5.71
	1-3	2.86	2.86	0.00	2.86
	4-6	2.86	2.86	10.01	10.00
	7-9	5.72	8.58	11.43	7.14
	10-12	80.00	75.72	70.01	74.28
73-74	0	5.71	7.14	7.14	7.14
	1-3	4.29	5.72	4.29	4.29
	4-6	8.58	10.01	12.86	11.43
	7-9	52.86	55.72	61.43	58.57
	10-12	28.58	21.43	14.29	18.58
74-75	0	7.14	8.57	8.57	8.57
	1-3	4.29	5.72	4.29	4.29
	4-6	7.15	8.58	12.86	12.86
	7-9	55.71	52.86	62.86	58.57
	10-12	25.72	24.29	11.43	15.72
75-76	0	7.14	8.57	7.14	7.14
	1-3	7.15	7.15	5.72	7.15
	4-6	4.29	7.15	14.28	12.85
	7-9	22.86	31.43	42.85	41.43
	10-12	58.57	45.71	30.00	31.42
76-77	0	0.00	2.86	1.43	1.43
	1-3	7.14	5.72	7.15	7.14
	4-6	4.29	4.29	4.29	4.29
	7-9	14.29	20.00	30.00	27.14
	10-12	74.28	67.14	57.14	60.00
77-78	0	10.00	11.43	12.86	11.43
	1-3	4.29	7.15	8.57	10.01
	4-6	5.72	5.72	2.86	1.43
	7-9	20.00	20.00	21.43	14.29
	10-12	60.00	55.72	54.29	62.86
78-79	0	5.71	5.71	5.71	5.71
	1-3	2.86	5.72	2.86	1.43
	4-6	5.72	4.29	5.72	5.72
	7-9	17.15	21.42	18.56	17.14
	10-12	68.57	62.86	67.15	70.00
79-80	0	5.71	5.71	5.71	5.71
	1-3	5.72	7.14	7.14	4.29
	4-6	5.72	4.29	1.43	4.29
	7-9	7.14	10.00	10.01	8.58
	10-12	75.72	72.86	75.72	77.14
80-81	0	11.43	11.43	8.57	8.57
	1-3	4.29	5.72	7.15	5.72
	4-6	1.43	2.86	7.15	7.15
	7-9	7.14	4.29	21.44	17.14
	10-12	75.71	75.72	55.72	61.43
81-82	0	4.29	4.29	5.71	4.29
	1-3	7.14	8.58	7.15	4.29
	4-6	11.43	17.13	25.71	24.28
	7-9	45.71	42.87	42.86	45.71
	10-12	31.43	27.15	18.58	21.43

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	6.04	7.25	6.59	5.93
MEDIAN	0	5.71	7.14	7.14	5.71
ST. D.	0	3.60	3.52	3.67	3.77
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	4.62	5.17	5.06	4.73
MEDIAN	1-3	4.29	5.72	5.72	4.29
ST. D.	1-3	2.03	2.65	2.95	2.70
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	4.84	6.16	8.58	8.13
MEDIAN	4-6	4.29	5.72	5.72	5.72
ST. D.	4-6	3.12	4.05	6.62	6.32
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	24.51	26.16	31.65	29.78
MEDIAN	7-9	20.00	21.42	30.00	27.14
ST. D.	7-9	18.09	17.19	18.82	19.44
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	60.00	55.28	48.14	51.43
MEDIAN	10-12	68.57	62.86	54.29	60.00
ST. D.	10-12	21.52	22.22	25.03	25.13

Table 9.

HSI'S FROM WOOD STORK MODEL BY YEAR

YEAR	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVEN
1970	0	0	0
1971	0.63	0.62	0.52
1972	0	0	0
1973	0.42	0.62	0.11
1974	1	1	1
1975	0.97	1	0.93
1976	0	0	0
1977	0.86	0.84	0.65
1978	0	0	0
1979	0	0	0
1980	0	0	0
1981	0.38	0.86	0.11
1982	0	0	0
AVERAGE =	0.33	0.38	0.26

Table 10a. A prediction of wading bird colony site nesting success for the period 1969-1982, for natural versus four proposed water delivery alternatives for the Shark Slough GDM (M. Fleming).

COLONIES	NATURAL	BASE	MOD. BASE	RAINFALL	MOD. RAINFALL
Site 1	93%	0%	0%	0%	0%
Site 2	86%	71%	57%	36%	57%
Site 3	86%	71%	86%	43%	64%
Mean 14-year rate colony success	88%	47%	48%	26%	40%

Table 10b. A comparison of simulated alligator population parameters for natural versus proposed, experimental water delivery alternatives for the Shark Slough GDM evaluation area.

Water Deliveries	Population Estimates Average	Maximum	Minimum	Average % Nest. Success	% Freq. Sign. Nest Flooding
Natural	178000	350000	125000	93	7
Base	116300	152000	925000	81	19
Mod. Base	124600	155000	95000	72	28
Rainfall	131750	155000	92500	69	31
Mod. Rainfall	125250	155000	92500	68	32

Table 11.
HSI'S FROM SNAIL KITE MODEL BY CELL

CELL COORDINATES X	Y	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVE
16	31	0	0	0
19	31	0	0	0
22	31	0	0	0.46
25	31	0.7	0.698	0.71
18	29	0	0	0
21	29	0.272	0.346	0.368
24	29	0.788	0.408	0.416
17	27	0.416	0.426	0.44
20	27	0.416	0.536	0.464
23	27	0.72	0.724	0.418
16	25	0	0	0.444
19	25	0.56	0.562	0.756
22	25	0.414	0.416	0.73
17	23	0.652	0.666	0.716
20	23	0.408	0.412	0.72
27	29	0	0	0
26	27	0	0	0
25	25	0.66	0.712	0.664
23	23	0.79	0.808	0.826
26	23	0	0	0
16	21	0	0	0
19	21	0.314	0.372	0
22	21	0	0.332	0.648
25	21	0	0	0.41
17	19	0	0	0
20	19	0	0	0
23	19	0	0	0.3
26	19	0	0	0
16	17	0	0	0
19	17	0	0	0
22	17	0	0	0
25	17	0	0	0
15	15	0	0	0
18	15	0.474	0.4	0.314
21	15	0	0	0
24	15	0	0	0
14	13	0	0	0
17	13	0.288	0	0
20	13	0	0	0
23	13	0	0	0
AVERAGE =		0.1968	0.19545	0.2451
NUMBER OF CELLS HSI > .5		7	7	8

Table 12.
HSI'S FROM ALLIGATOR MODEL, BY CELL

CELL COORDINATES X	Y	BASE	MODIFIED MINIMUM	MODIFIED RAINDRIVEN
16	31	0.611	0.611	0.619
19	31	0.674	0.677	0.685
22	31	0.724	0.725	0.730
25	31	0.762	0.761	0.754
18	29	0.705	0.705	0.709
21	29	0.733	0.747	0.754
24	29	0.796	0.823	0.816
17	27	0.747	0.749	0.751
20	27	0.753	0.765	0.769
23	27	0.811	0.807	0.800
16	25	0.721	0.722	0.726
19	25	0.766	0.766	0.771
22	25	0.826	0.827	0.818
17	23	0.778	0.780	0.779
20	23	0.826	0.828	0.825
27	29	0.589	0.592	0.603
26	27	0.656	0.661	0.675
25	25	0.768	0.777	0.775
23	23	0.776	0.778	0.782
26	23	0.616	0.641	0.659
16	21	0.581	0.594	0.569
19	21	0.730	0.741	0.728
22	21	0.618	0.718	0.771
25	21	0.483	0.618	0.704
17	19	0.659	0.665	0.641
20	19	0.686	0.678	0.693
23	19	0.519	0.619	0.708
26	19	0.263	0.263	0.000
16	17	0.614	0.565	0.586
19	17	0.646	0.608	0.639
22	17	0.433	0.471	0.502
25	17	0.263	0.271	0.000
15	15	0.564	0.556	0.566
18	15	0.733	0.714	0.737
21	15	0.325	0.325	0.372
24	15	0.419	0.446	0.394
14	13	0.578	0.568	0.597
17	13	0.736	0.714	0.758
20	13	0.311	0.311	0.316
23	13	0.463	0.463	0.464
	AVERAGE =	0.632	0.641	0.639

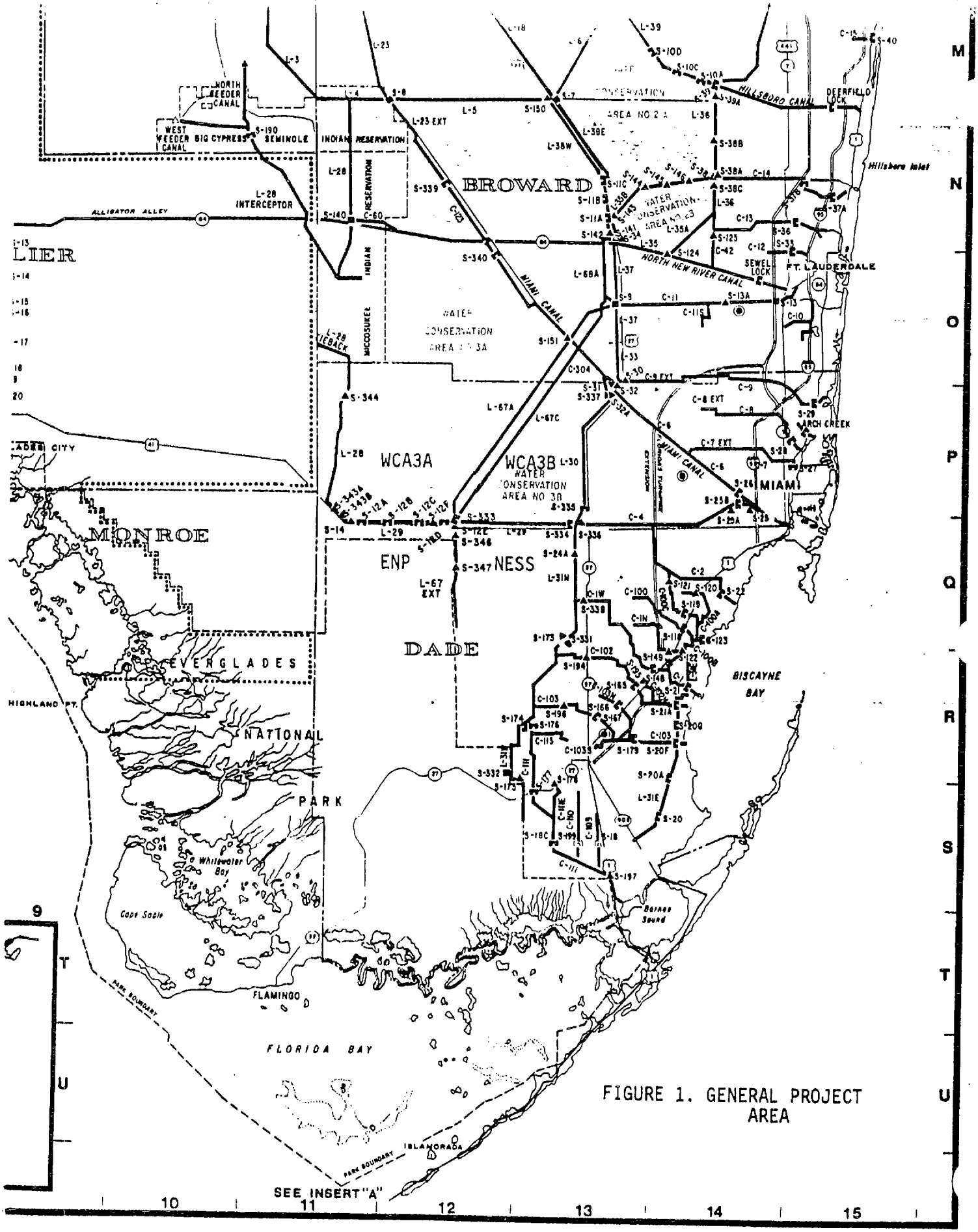

FIGURE 1. GENERAL PROJECT AREA

FWCA REPORT

APPENDIX A

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

BIOLOGICAL OPINION
MODIFIED WATER DELIVERY TO EVERGLADES NATIONAL PARK

U.S. Department of the Interior
Fish and Wildlife Service

Appendix A:
Biological Opinion and Wood Stork Model

D-62

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA
30303

TAKE PRIDE IN AMERICA

February 13, 1990

Colonel Bruce A. Malson
District Engineer
U.S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Malson:

This represents the Biological Opinion of the U.S. Fish and Wildlife Service (Service) pursuant to Section 7 of the Endangered Species Act of 1973, as amended, regarding your General Design Memorandum for an Improved Water Delivery System to Everglades National Park, Florida. This Opinion satisfies only the consultation requirements of Section 7(a)(2) of the Endangered Species Act (Act) of 1973 as amended, regarding the (Everglade) snail kite (Rostrhamus sociabilis plumbeus) and the wood stork (Mycteria americana). It does not address other environmental statutes such as the Fish and Wildlife Coordination Act and National Environmental Policy Act. An administrative record of this consultation is on file in the Service's Vero Beach, Florida, Field Office.

Sincerely yours,

Howard V. Lubber

for James W. Pulliam, Jr.
Regional Director

Enclosure

cc:
CE, Division, Atlanta, GA
EPA, Atlanta, GA
NMFS, St. Petersburg, FL
FGFWFC, Tallahassee, FL
FGFWFC, Vero Beach, FL
NPS, Atlanta, GA
ENP, Homestead, FL
SFWMD, West Palm Beach, FL

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PROJECT DESCRIPTION

The project objectives are to restore historic hydrologic conditions in Everglades National Park (Park). These include the timing and duration of flows, and the spatial distribution of surface water. The Corps of Engineers' (Corps) "General Plan for Implementation of an Improved Water Delivery System to Everglades National Park, Florida" (1985) notes that timing and duration of flows can be improved by two approaches: (1) varying the rates of water deliveries according to rainfall and stage conditions upstream of the Park; and (2) manipulating water deliveries according to ecological conditions desired in the Park. There are four project alternatives under consideration. The first is the no-action alternative or Base condition. The second (Modified Minimum Delivery) uses the ecological approach to establish conditions for the Park and neighboring wetlands. The third is based exclusively on the restoration of natural flows to the Park (Basic Raindriven Plan). The last augments natural water deliveries with supplementary flows needed for maintenance of upstream habitats. (Modified Raindriven Plan).

Another project objective is to reduce impacts from abrupt release of water which occurs under the Base condition. All of the action alternatives do this, largely by spreading flows across a broader front. This redirection of flows also provides more natural spatial distribution of water. Thus, all of the action alternatives under consideration appear to satisfy the stated project objectives.

BASE CONDITION

The no-action alternative would make use of the current water delivery structures. Under this Base condition water is delivered according to a formula approved by Congress in 1970 and designed to guarantee at least a minimally adequate flow into the Park. All other alternatives require installation of new structures and management plans.

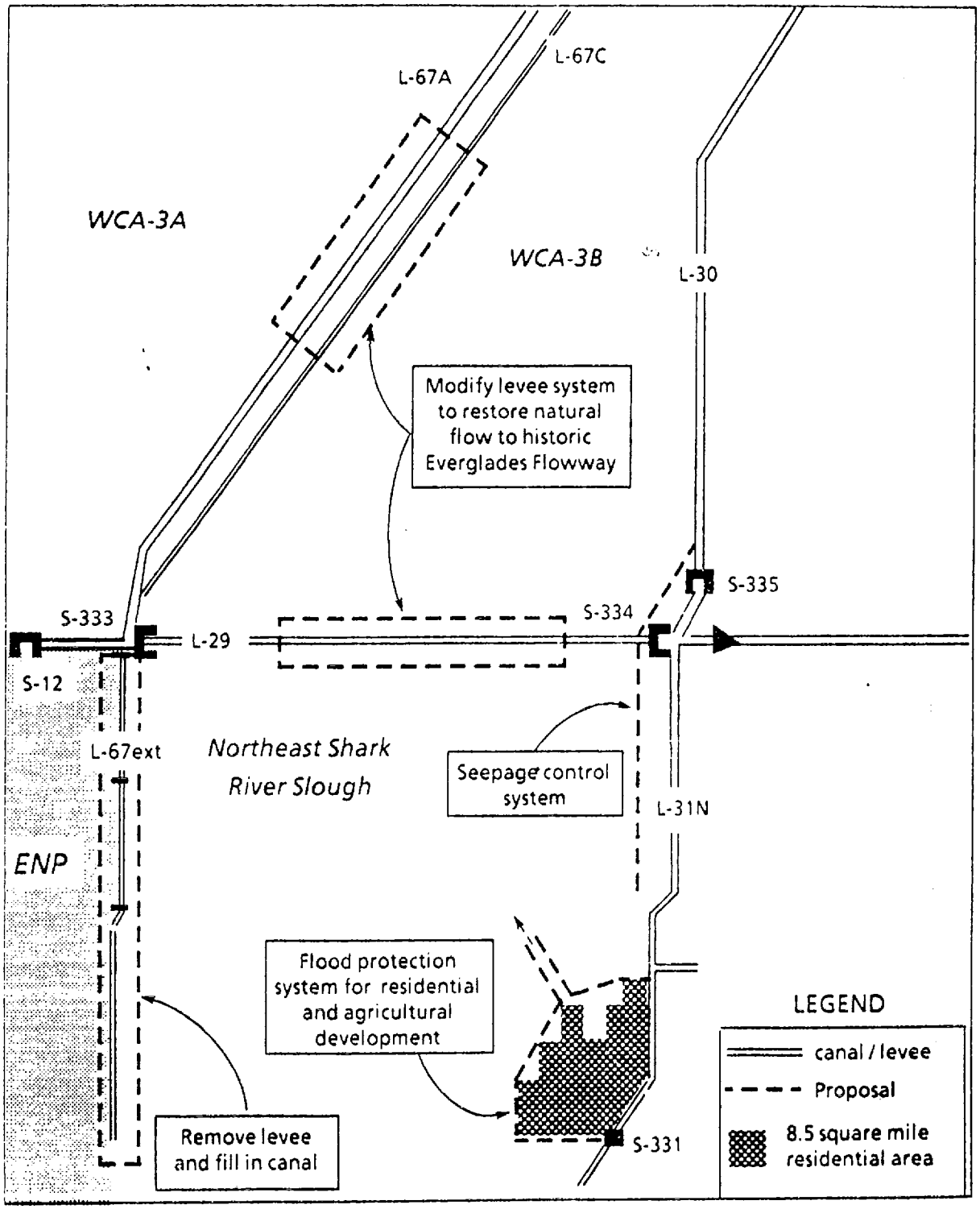
MODIFIED MINIMUM DELIVERY

This is the simplest plan both structurally and in operation. New features would include elimination of the levee (L-67x) separating the "chimney" of the Park from Northeast Shark Slough (NESS), replacing it back into the adjacent canal (see Figure 1a). A flood protection levee would be built around the residential portion of NESS, and drainage would be provided by pumping into the L-29 canal. Water deliveries to the Park would be the same as under the Base condition.

BASIC RAINDRIVEN PLAN

The Basic Raindriven alternative also removes the L-67x levee and installs flood protection levees and pumps. Additionally, six gated structures would be installed in Water Conservation Area 3A (WCA3A) to reduce canal conveyance to the south (forcing water to spread out more extensively), and

FIGURE 1a **East Everglades GDM**
Conceptual Plan



to divert most of these flows through Water Conservation Area 3B (WCA3B). Two additional structures would send water south out of WCA3B into NESS. Under the Basic Raindriven Plan, water is delivered to the Park using a formula based on precipitation in the basin upstream of the Park. This means that flows can vary widely. In droughts (typically at 5-7 year intervals) water deliveries may cease entirely (as occurred throughout most of 1989, under experimental raindriven operations).

MODIFIED RAINDRIVEN PLAN

Because hydrologic modeling of the Basic Raindriven Plan showed significant drainage of WCA3A, the Corps and Service developed a Modified Raindriven Plan. This alternative uses the same structures as the Basic Raindriven Plan, and delivers water to the Park according to the same formula. To conserve water in WCA3A, the Modified Raindriven Plan does not use the obstructions in the L-67a canal, but does have the connections with WCA3B. Also, during droughts, water consumption from WCA3A is cut back, and supplemental deliveries from Lake Okeechobee are initiated at an earlier stage. However, because the schedule of deliveries to the Park is controlled by local rainfall, the overall water demand on Lake Okeechobee is lower than under the Base plan, especially in drought years (Figure 1b).

All of the major changes from this project are of a hydrologic nature, and it is widely recognized that stage, duration, and timing of flooding events have a profound influence on the Everglades ecosystem. Fortunately, a Surface Water Model was developed by the South Florida Water Management District for the Central and South Florida Flood Control Project. This was the primary source of predictive information about water stages which are likely to occur under all project alternatives. The model was operated by the Corps and the data, representing conditions as they would have occurred under each project alternative, were provided to the Service. These included end of month stages for the 14-year period of record, hydroperiod, and average flooding conditions for a study area covering over 1,200 square miles.

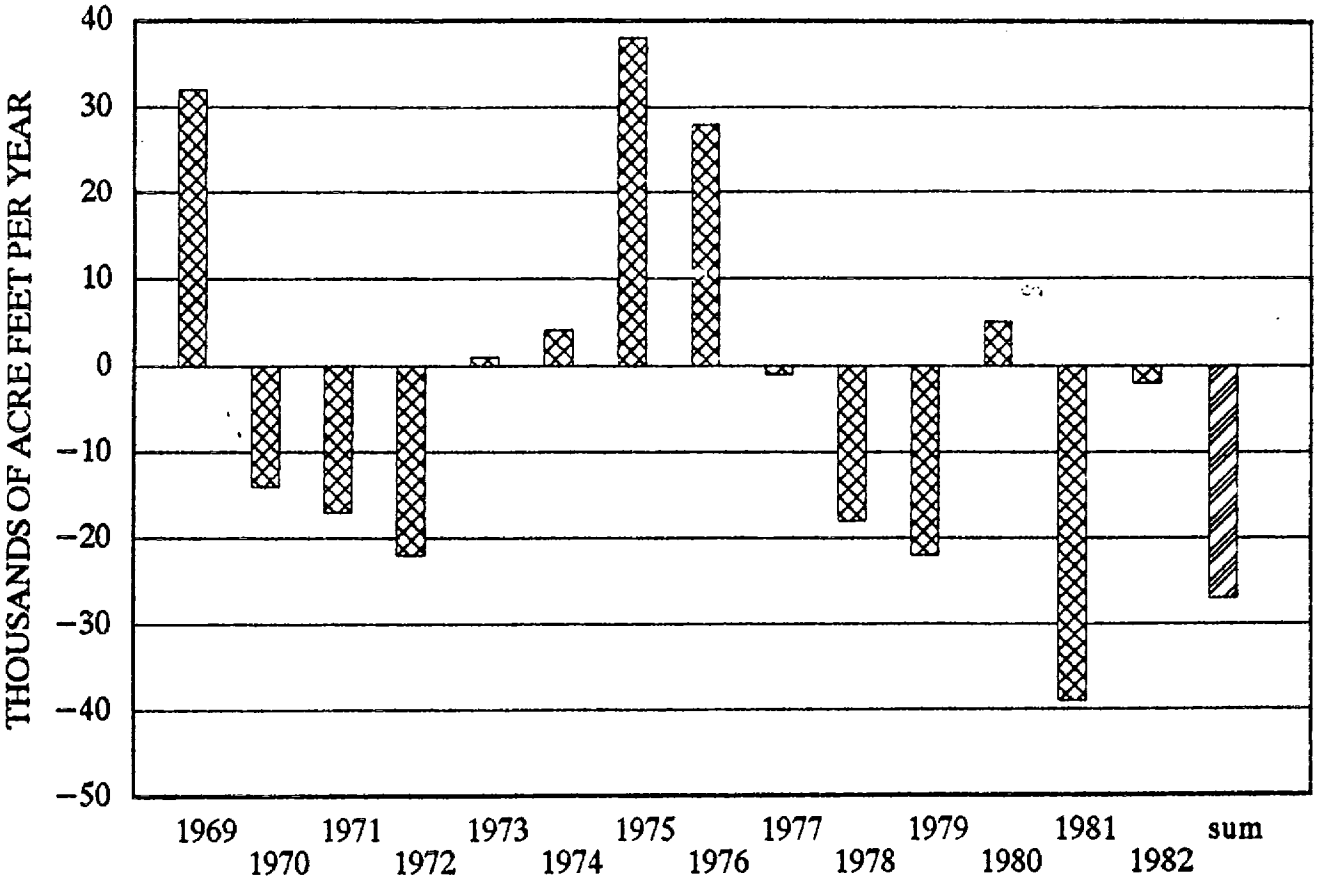
CONSULTATION HISTORY

Several alternative water delivery schedules have actually been field tested during the planning phase of this project (a flow-through scheme, in which WCA3A was allowed to freely drain into the Park, and a tentative version of the currently proposed Raindriven Plan). Field testing was underway prior to initiation of consultation under the Act.

Hydrologic changes in the Water Conservation Areas, NESS, and the Park are presently of concern because of potential impacts on federally listed endangered species and other wildlife. WCA3A and part of the Park are

FIGURE 1b WATER WITHDRAWAL FROM LAKE OKEECHOBEE

MODIFIED RAINDRIVEN MINUS BASE



BASED ON MONTHLY VOLUME DIFFERENCES

designated Critical Habitat for the snail kite (Rostrhamus sociabilis plumbeus). The kite is found in wetlands having relatively long hydroperiods which are required by its prey, the apple snail. The Water Conservation Areas and Park also are critical feeding areas for wood storks (Mycteria americana). Wood storks depend on hydrologic conditions which favor production of forage fishes and concentrate prey during the spring breeding season. Analyses of hydrologic impacts, therefore, were central to the Service's assessment of impacts on the species and their habitats.

The first interagency discussion of potential impacts from the field testing occurred on March 28, 1985. Focus was on the snail kite, then suffering from the effects of a severe drought. Proponents held that the field tests should raise water levels in WCA3A, and that this would either be beneficial to or have no impact upon the snail kite. Based partly on this, the Corps sent the Service a letter on April 22, 1985, stating its determination that the field testing would have no adverse effect on any listed species.

At a meeting on May 2, 1985, the Service proposed research and monitoring on snail kite use of WCA3A. This position was reiterated in a letter sent to the Corps on May 13, 1985, in which the Service disagreed with the determination of no effect on both the snail kite and the wood stork. Since the latter species already was being monitored by the Park, it was argued that an equivalent effort should be made for the snail kite.

On May 31, 1985, the Corps formally advised the Service of its intent to modify the operation of structures directing water to the Park, and stated that this modification would not have adverse effects on listed species or designated Critical Habitat. The Service responded on June 5, 1985. Based upon the Corps' agreement to implement a snail kite monitoring plan, and in recognition of the experimental and temporary nature of this field test, the Service then concurred with the determination of "no effect." That letter advised that it might be necessary to reinitiate consultation if it were found that the experiment had adverse effects on snail kites, or if the water schedule was to become permanent.

In the spring of 1988, the Service reviewed a draft report describing the 2 years of monitoring of snail kite nesting success in WCA3A (Bennetts, et al. 1988). The Service also analyzed the potential impacts of the project using data from the Surface Water Model and a habitat suitability model developed for the snail kite. Based upon the above new information, the Service found it necessary to reinitiate consultation on the kite population and the designated Critical Habitat in WCA3A, as stated in our letter of May 19, 1988. This Biological Opinion has been developed pursuant to that finding, and the new description of project alternatives sent by the Corps on November 21, 1989.

BIOLOGICAL OPINION

Snail kite

The snail kite is found in Florida's Everglades and Cuba, with other subspecies occurring in parts of Central and South America. In the United States the snail kite is endangered. It has experienced pronounced population fluctuations (over the past 20 years United States numbers have ranged from 21 to just over 600 individuals), primarily associated with hydrologic influences, both man-induced and natural (Sykes 1983a; Beissinger and Takekawa 1983; Beissinger 1986). This kite is tied to a highly specialized molluscan diet (for which it was named). The abundance of its prey, apple snails, is closely linked to water regime (Kushlan 1975; Sykes 1979, 1983a). Drainage of Florida's interior wetlands has reduced the extent and quality of habitat for the snail and the raptor (Sykes 1983b). Also, the kite nests over water, and nests become accessible to predators in the event of unseasonal drying (Beissinger 1986; Sykes 1987c). In dry years the kite depends on water bodies which normally are suboptimal for feeding, such as canals, impoundments, or small marsh areas, remote from regularly used sites (Beissinger and Takekawa 1983; Bennetts, et al. 1988; Takekawa and Beissinger 1989). These secondary or refuge habitats are vital to continued survival of this species in Florida.

General life history

Though snail kites historically ranged throughout most of Florida (Sykes 1984) they currently utilize lakes and sloughs within the Kissimmee-Okeechobee-Everglades system, marshes and impoundments in the headwaters of the St. Johns River, and some outlying sloughs and wet prairies in the south-central part of the State.

Kites construct nests in snags, trees, shrubs or tall emergent vegetation (Sykes 1987a, 1987c; Bennetts, et al. 1988). Nesting occurs primarily between March and May. While rearing young, the adults forage no more than six km from the nest (Beissinger and Snyder 1987), and generally less than a few hundred m (J. Rodgers, Jr., pers. comm.). At other times kites loosely aggregate at roosts (which often are used as nest sites; Sykes 1985), and range 1.5 - 2 km for feeding.

The snail kite generally feeds in water depths ranging from 0.2 to about 1.0 m in areas having fairly sparse emergent vegetation. Prey is located either by "coursing" or by still hunting (Sykes 1987b). In the former the bird surveys relatively large areas, diving and capturing prey sighted during flight, then alighting on a perch (which may be only emergent vegetation; Sykes 1987b) to remove the snail from its shell. When perch hunting the bird watches for snails from an elevated platform and swoops down, returning to that perch after an attempt at capture.

Florida experiences drought episodes at a frequency of 5 to 10 years Sykes 1983b; Beissinger 1986). In drought conditions kites will migrate

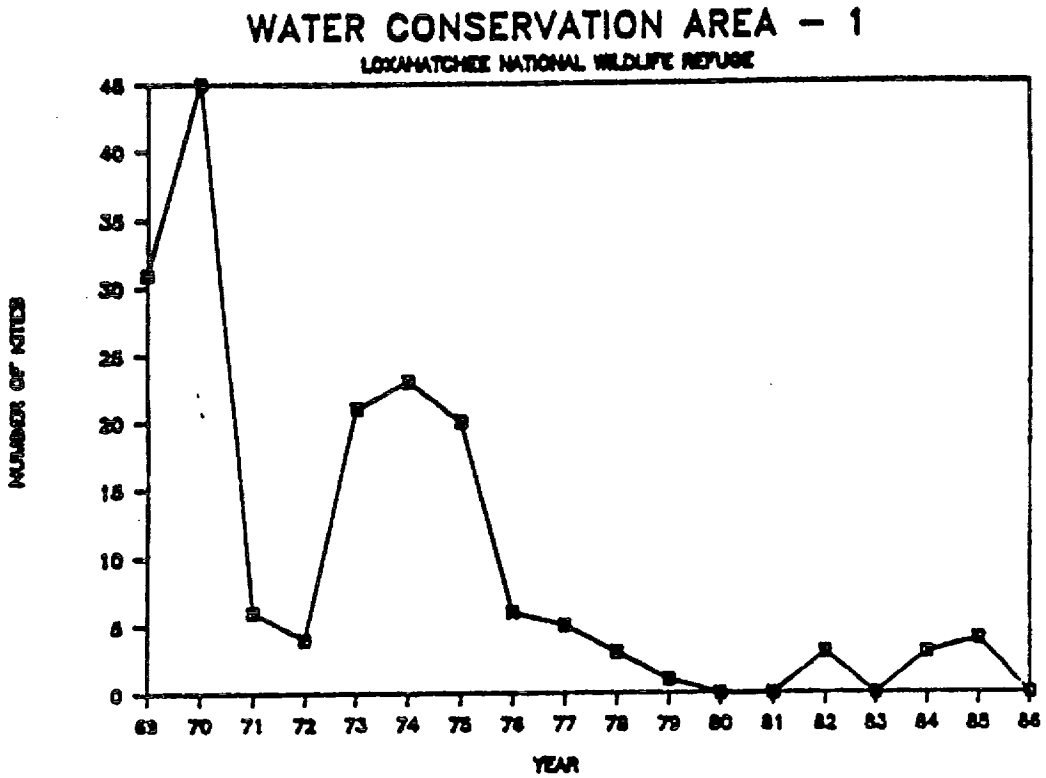
to areas generally less preferred but still offering food supplies, even to urban situations (Beissinger and Takekawa 1983; Takekawa and Beissinger 1989). While dispersal may be an effective response to local adversity, Region-wide droughts cause precipitous declines in the kite population. Periodic drought and drainage of wetlands, with the attendant loss of the prey base, appear to be the overall limiting factor for kites in Florida (Beissinger 1986; Sykes 1987b).

Hydrologic requirements

The growth and maintenance of emergent vegetation used for roosting and nesting (and egg substrate for snails) requires aerial exposure of the soil at a frequency of no less than once in about every 5 years. However, apple snails do not fair well in areas that dry out more frequently than once every 18 months. Thus, primary snail kite habitat occurs within a fairly narrow range of hydroperiod conditions. Historically, these conditions occurred in Lake Okeechobee (still a stronghold of the kite), and in deeper regions of the Everglades. In modern times suitable conditions occur in the longer hydroperiod portions of the Water Conservation Areas. Arthur R. Marshall Loxahatchee National Wildlife Refuge and WCA2A briefly (1960's to mid 1970's) hosted most of kites in the United States, until water management practices increased the frequency of drying events. Kite use of these areas has been negligible since that time (Figure 2a). In recent years a great deal of the southern third of WCA3A had appropriate hydroperiods, and up to 90 percent of the snail kites in the United States made use of this portion of their designated Critical Habitat (Figure 2b).

While occasional drying events rejuvenate emergent vegetation, these events also deprive kites of their food supplies. Snails survive short droughts by burrowing into the substrate, but are decimated by prolonged drying. Thus, frequent droughts drive kites from primary habitat, and prolonged droughts extend the time for the snail population to recover (Takekawa and Beissinger 1989). During droughts kites disperse and seek refugia where snails can be obtained. Drought refugia are generally long-term flooded areas which remain wet even during low rainfall years, and so have accessible snail populations. Beissinger and Takekawa (1983) used the term to mean long-hydroperiod wetlands outside the Water Conservation Areas. However, wetlands within the Water Conservation Area which remain flooded during drought serve the same purpose (Beissinger, pers. comm.). According to Takekawa and Beissinger (1989), and observations of Paul Sykes and Steven Beissinger (personal communications), the snail kite population of south Florida probably is limited by the availability and quality of such refugia rather than the availability of the primary habitat. For this reason, this Biological Opinion focuses on potential impacts of the project on refugia habitat.

FIGURE 2a. SNAIL KITE USE OF ARTHUR R. MARSHALL LOXAHATCHEE NWR AND WCA2A
(from Bennetts et al. 1988)



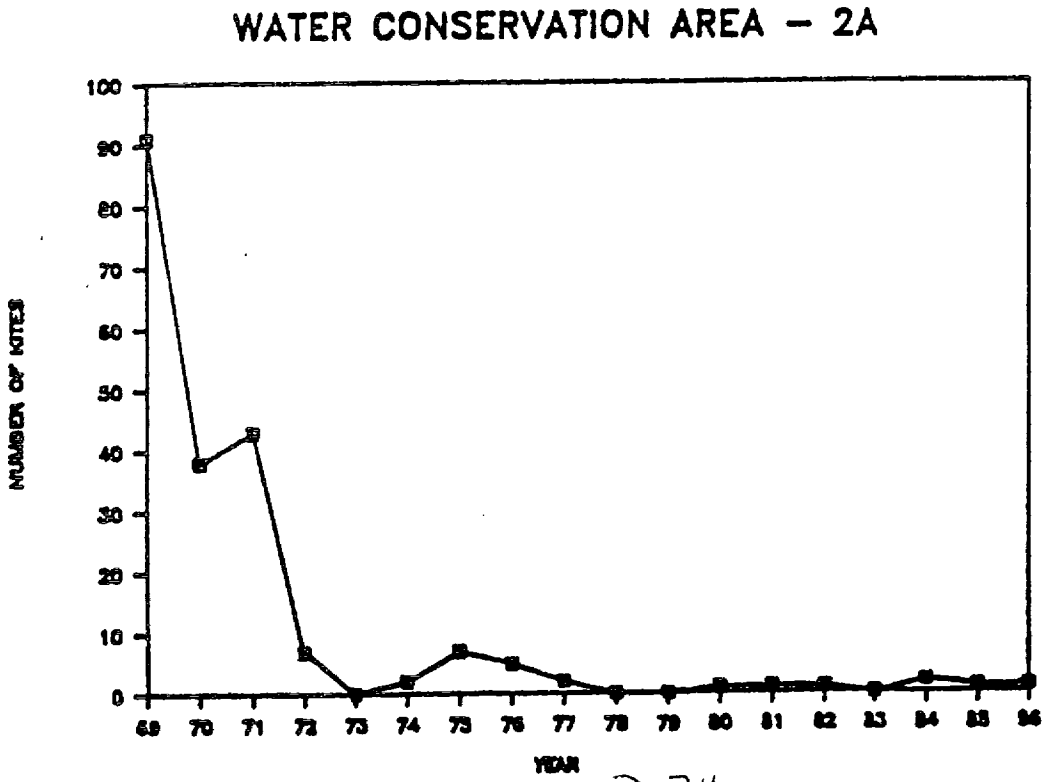
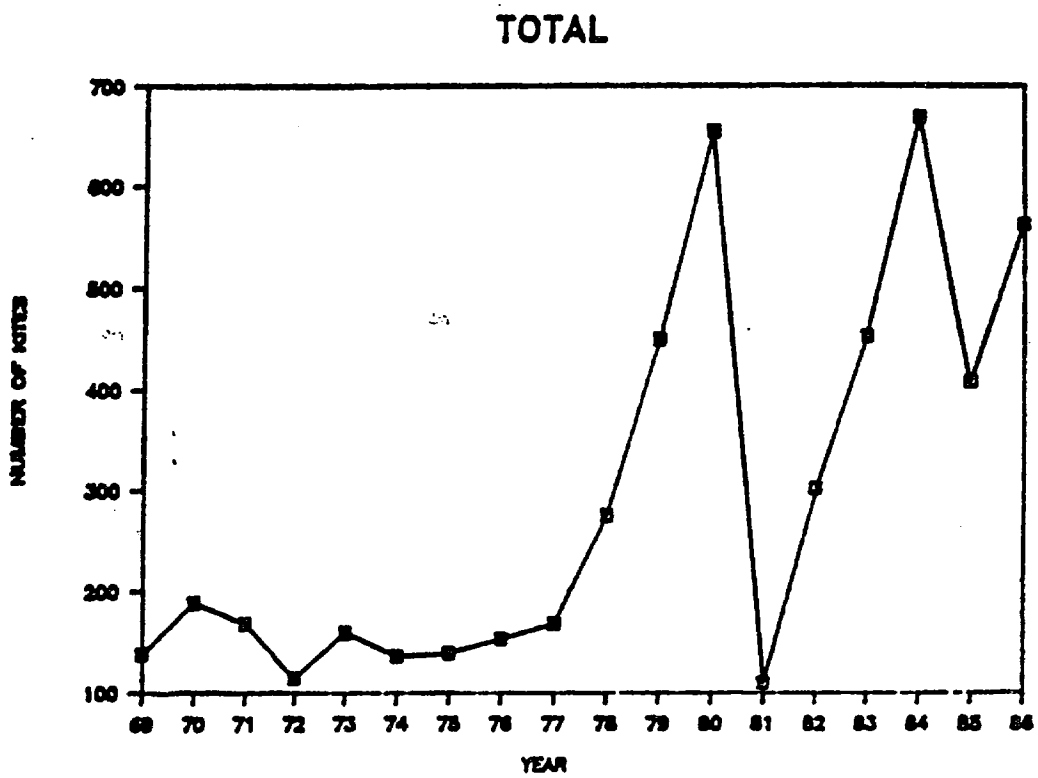
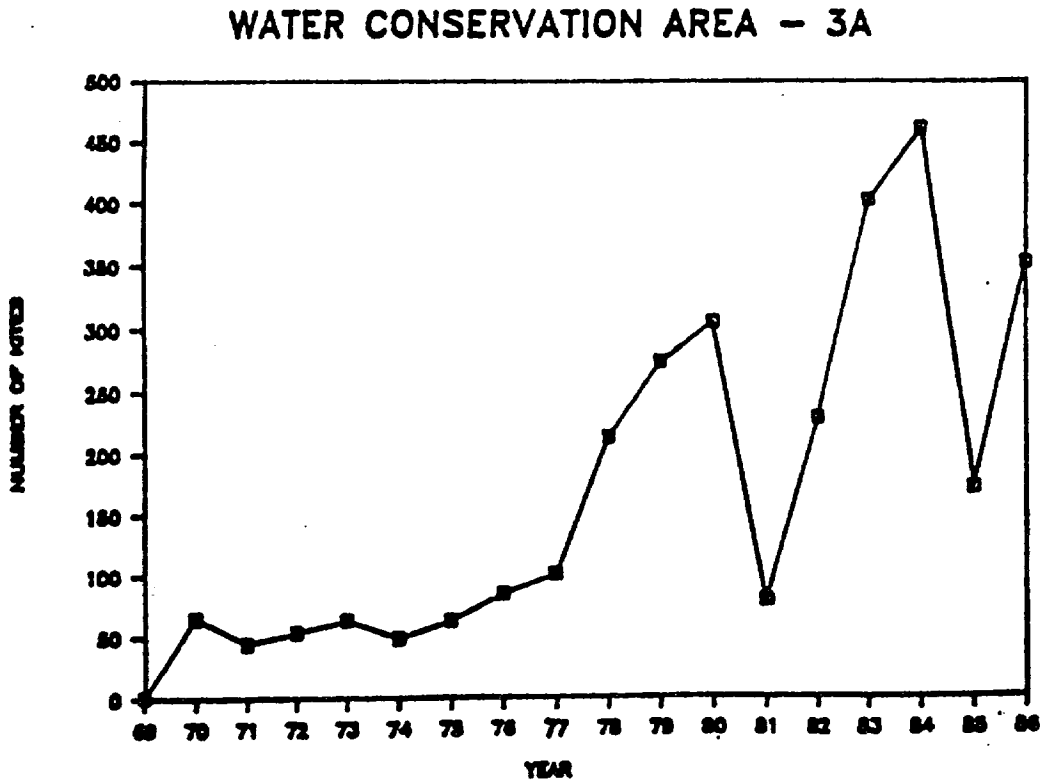


FIGURE 2b. SNAIL KITE USE OF WCA3A, AND TOTAL POPULATION
(from Bennetts et al. 1988)





Impact assessments

The snail kite study by Bennetts, et al. (1988) dealt primarily with nesting success in WCA3A during 1986 and 1987. Findings included: the number and distribution of nests in each year; the number of young produced; and the associated vegetation patterns and hydrologic conditions. The study also examined impacts from nest predation. The authors used these data and information from other studies to assess potential impacts to the kite from several project alternatives and to recommend courses of action. Two Raindriven alternatives were reviewed. The first project alternative (called the "basic" plan by Bennetts, et al.) did not have structures blocking the L-67 canal. This alternative apparently had minor hydrologic impacts and was judged to be innocuous to the kite. The alternative with these structures (components of both current Raindriven plans) sharply increased the frequency of drying events. Bennetts, et al. stated that this plan would:

> ". . . result in shorter dry-down intervals. More frequent dry-outs of WCA-3A will increase the frequency, of kite dispersal, which may result in population declines (Beissinger and Takekawa 1983, Beissinger 1986, Takekawa and Beissinger 1989) and shorten the time between droughts for the kite population to recover (due to lag year effects on food supplies). This would speed up the oscillations of population cycles of the kite, probably resulting in a downward cycling trend (because of the lack of sufficient recovery time from dry-down induced mortality events)."

In the face of such a negative review, we undertook our own detailed analysis of the hydrologic conditions as modeled for each alternative. Also, we worked with Corps hydrologists and project managers to develop several new alternatives which could meet the expressed objectives of the project, without such adverse effects on the kite.

The Service's analysis covered four main areas of the historic Everglades: WCA3A, WCA3B, NESS, and the main body of Shark River Slough in the Park. Figure 3 is a grid cell map of the project area with the Surface Water Model cell network superimposed. Each cell is 4 square miles, and data were provided us representing the end of month stage for each cell for the entire 14 years. Data also were sent to us representing the average duration of flooding events for each cell for the 14 years. This is a measure of hydroperiod, but is expressed in years, rather than days, as more commonly expressed. We found that only WCA3A and WCA3B retained water for long enough periods to be considered persistent habitat under any of the alternatives being considered. Indeed, under the Base alternative 48 square miles of wetlands are available, with a hydroperiod exceeding 6 years. Impacts to the kite, therefore, would be associated with reduction in hydroperiod in the Water Conservation Areas.

The effects of the project were estimated by comparing conditions for the Base run to those for the three other alternatives being considered by the Corps. The most direct comparison can be made by viewing hydroperiod maps for the four alternatives. Figures 4,5,6 and 7 display hydroperiod values

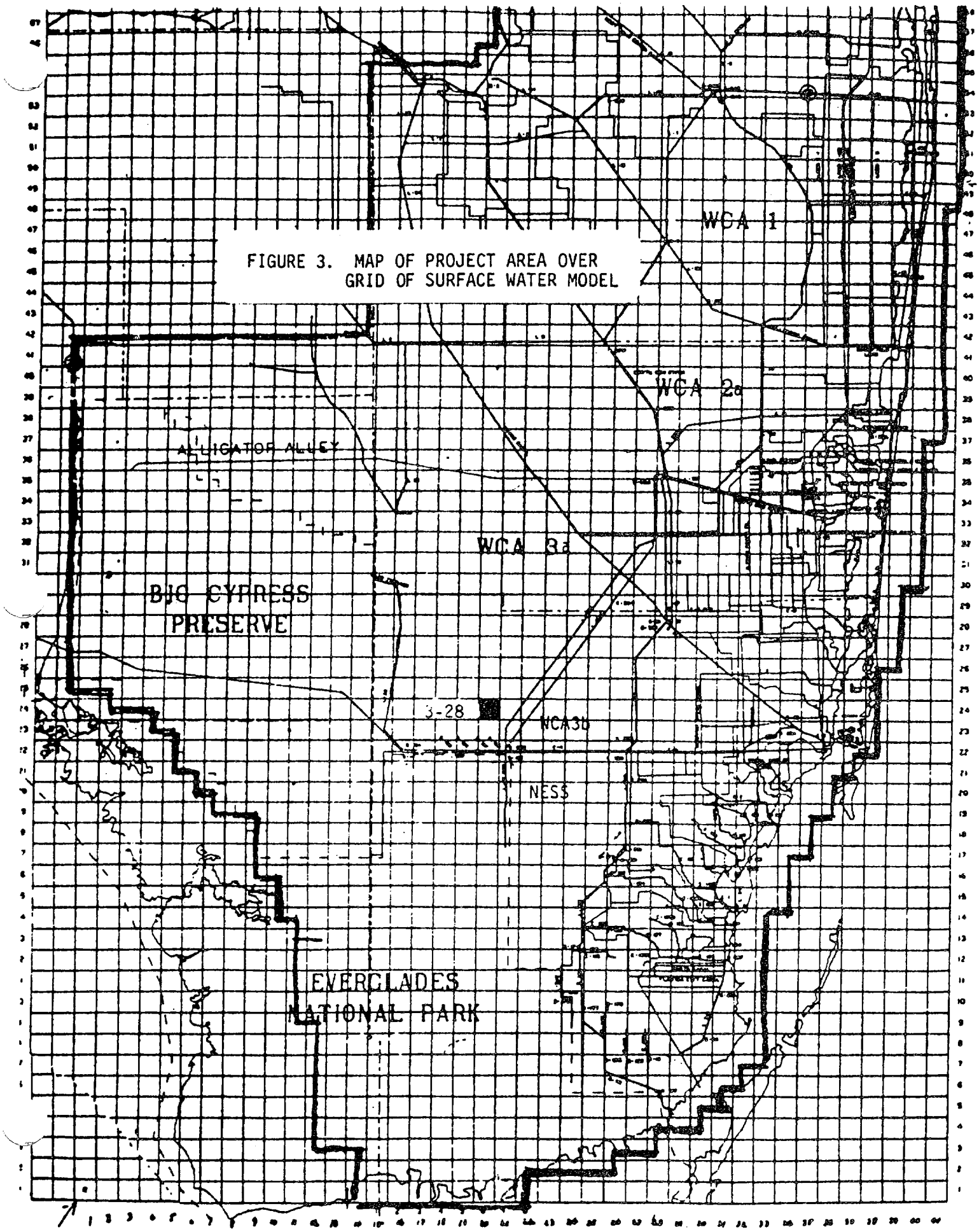


FIGURE 3. MAP OF PROJECT AREA OVER GRID OF SURFACE WATER MODEL

for each cell in the project area. Under the Base (Figure 4) the southeastern border of WCA3A, the northwestern border of WCA3B, and the pocket between them have relatively long hydroperiods. With the Modified Minimum (Figure 5) hydroperiod of some cells actually increases slightly in the WCA's and to the south, in NESS and the Park. The Basic Raindriven (Figure 6) loses all persistent habitat, even though hydroperiod to the south is about the same as with the Modified Minimum. The Modified Raindriven (Figure 7) has no cells which remain flooded over the 14-year period; habitat available during drought is about half the area and half the duration of the Minimum Delivery alternatives. These observations are displayed graphically in Figure 8.

It is apparent that spreading water out in WCA3A (due to the structures in the L-67 canal) and diverting it through WCA3B reduces ponding in the Water Conservation Areas more than it increases hydroperiod in NESS and the Park. The augmented water supplies and cutbacks in consumption reduce this effect considerably in the Modified Raindriven.

Takekawa and Beissinger (1989) discuss effects of drought on snail kites and provide a measure of the species' response to drying of WCA3A in the 1985 drought. They plotted the number of sightings of kites in known drought refugia against water elevation at gauge 3-28, at the south end of WCA3A. The kite observations were of birds which had dispersed, probably most of them from WCA3A. The number of sightings was correlated with stage during the dry-down ($r=.967$, $P<.01$). The frequency of drying events at this gauge is presented below, for the four alternatives, as an index of effect on kites.

TABLE 1. DRYING OCCURRENCES AT GAUGE 3-28

ALTERNATIVE	NUMBER OF DRYING OCCURRENCES OVER A 14 YEAR PERIOD	AVERAGE FREQUENCY DRYING EVENTS
BASE	1	14.0 YEARS
MODIFIED MINIMUM	2	7.0 YEARS
BASIC RAINDRIVEN	6	2.3 YEARS
MODIFIED RAINDRIVEN	4	3.5 YEARS

Beissinger (1989) presented results from population modeling for kites in south Florida. He showed that a frequency of drying shorter than about 3.6 to 4 years could bring kites to extinction within 50 to 100 years. The above table shows that Base and Modified Minimum have "safe" drying frequencies, but the values for both Raindriven plans apparently could drive the kite population to extinction. On the other hand, the extent of drying under the Raindriven alternatives is not as severe as the above table indicates. This is because, though the Raindriven alternatives cause more frequent drying in the south end of WCA3A (at the gauge), the spreading out of water from the L-67 canal somewhat increases hydroperiod

FIGURE 4. HYDROPERIOD MAP; BASE CONDITION

HYDROPERIOD IN YEARS

Y COORD. \ X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
34	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.9	0.8	0.8	1	1.2	1.2	1.3	1.4	1.6	1.4	1.6	0.2
33	0.4	0.6	0.6	0.8	0.7	0.9	1	0.9	0.9	0.9	1	1.2	1.2	1.4	1.8	1.8	1.9	2.1	0.5
32	0.3	0.4	0.6	0.7	0.7	0.8	0.9	0.9	0.9	1	1	1	1.2	1.6	1.5	1.8	2.7	2.1	0.1
31	0.3	0.4	0.3	0.4	0.6	0.8	0.9	0.9	1	1	1.1	1.2	1.2	1.4	1.9	2.2	2.7	1.1	0.1
30	0.5	0.3	0.3	0.5	0.5	0.4	0.7	0.9	1	1.1	1.1	1.1	1.4	1.6	2.2	3.4	0.5	0.6	0.1
29	0.5	0.4	0.4	0.4	0.4	0.5	0.9	1	1.1	1.1	1.2	1.3	1.4	2.6	3.4	7	0.6	0.1	0.2
28	0.5	0.5	0.5	0.5	0.5	0.6	1.1	1.2	1.1	1.2	1.2	1.6	2.7	4.6	7	1.6	1	0.5	0.3
27	0.5	0.6	0.5	0.5	0.6	0.7	1.2	1.4	1.2	1.2	1.4	1.6	2.7	4.6	7	1.6	0.9	0.6	0.1
26	0.5	0.4	0.5	0.5	0.5	0.6	1.2	1.4	1.4	1.6	1.6	2.2	3.4	7	2.2	1.6	1	0.2	0.1
25	0.6	0.6	0.6	0.6	0.7	0.7	1.2	1.6	1.6	1.6	2.2	2.7	7	2.2	2.2	1.9	1.1	0.1	0.1
24	0.6	0.6	0.6	0.6	0.7	0.7	1.2	1.4	2.3	7	7	14	7	2.2	1.9	1.6	0.9	0.1	0.1
23	0.4	0.5	0.5	0.7	0.8	0.8	1.4	2.2	3.4	14	14	14	2.2	2.2	1.6	1.1	0.7	0.1	0.1
22	0.5	0.6	0.8	0.8	0.9	0.8	1	1.4	1.4	1.6	1.6	0	0	0	0	0	0	0	0
21	0.5	0.6	0.9	0.9	0.3	0.8	0.8	1	1.6	1.6	1	1.6	1.1	0.8	0.6	0.4	0.2	0.1	0.1
20	0.5	0.7	0.6	0.5	0.5	0.8	1	1.2	1.4	1.6	1.6	1.6	1.2	1	0.5	0.6	0.1	0.1	0
19	0.5	1	1.1	0.3	0.3	0.1	0.9	1.1	1.6	1.6	1.1	1.3	1.2	0.5	0.4	0.4	0.1	0	0
18	0.5	0.3	0.3	0.3	0.2	0.3	0.4	1	1.4	1.9	1.1	1.3	0.5	0.7	0.4	0.2	0.1	0	0
17	0.6	0.5	0.4	0.3	0.3	0.4	1	0.6	1.2	1	1.2	1.6	0.4	0.4	0.4	0.1	0.1	0	0
16		0.5	0.6	0.3	0.1	0.2	1.1	1	1.2	1.1	0.1	0.2	0.2	0.1	0.2	0.1	0	0	0
15		0.1	0.6	0.6	0.7	0.6	1.2	1.6	1.9	1.9	0.4	0.2	0.3	0.2	0.3	0	0	0	0
14			0.5	0.8	0.9	1.6	1.6	1.6	1.6	0.5	0.3	0.1	0.1	0.4	0.1	0	0	0	0
13					1.6	1.5	1.6	1.6	0.6	0.2	0.2	0.3	0.4	0.4	0.1				
12					1.4	1.9	1.6	1.6	0.3	0.2	0.4	0.4	0.6	0.3	0				
11					14	1.9	1.9	0.7	0.3	0.1	0.4	0.5	0.6	0.2	0.1				
10					14	1.9	1.8	1.4	0.5	0.3	0.2	0.2	0.1	0.1	0				
9					1.9	14	14	14	6.6	6.4	0.3	0.2	0.5	0.5	0.5				
8					2.2	2.2	2.1	1.5	0.4	0.3	0.4	0.2	0.6	1.2	0.7				
7					1.8	1.8	1.4	1.3	0.6	0.2	0.3	0.7	1.1	0.6	0.5				
6					1.8	1.8	1.4	1.3	0.8	0.3	0.7	0.6	0.7	0.5	0.5				

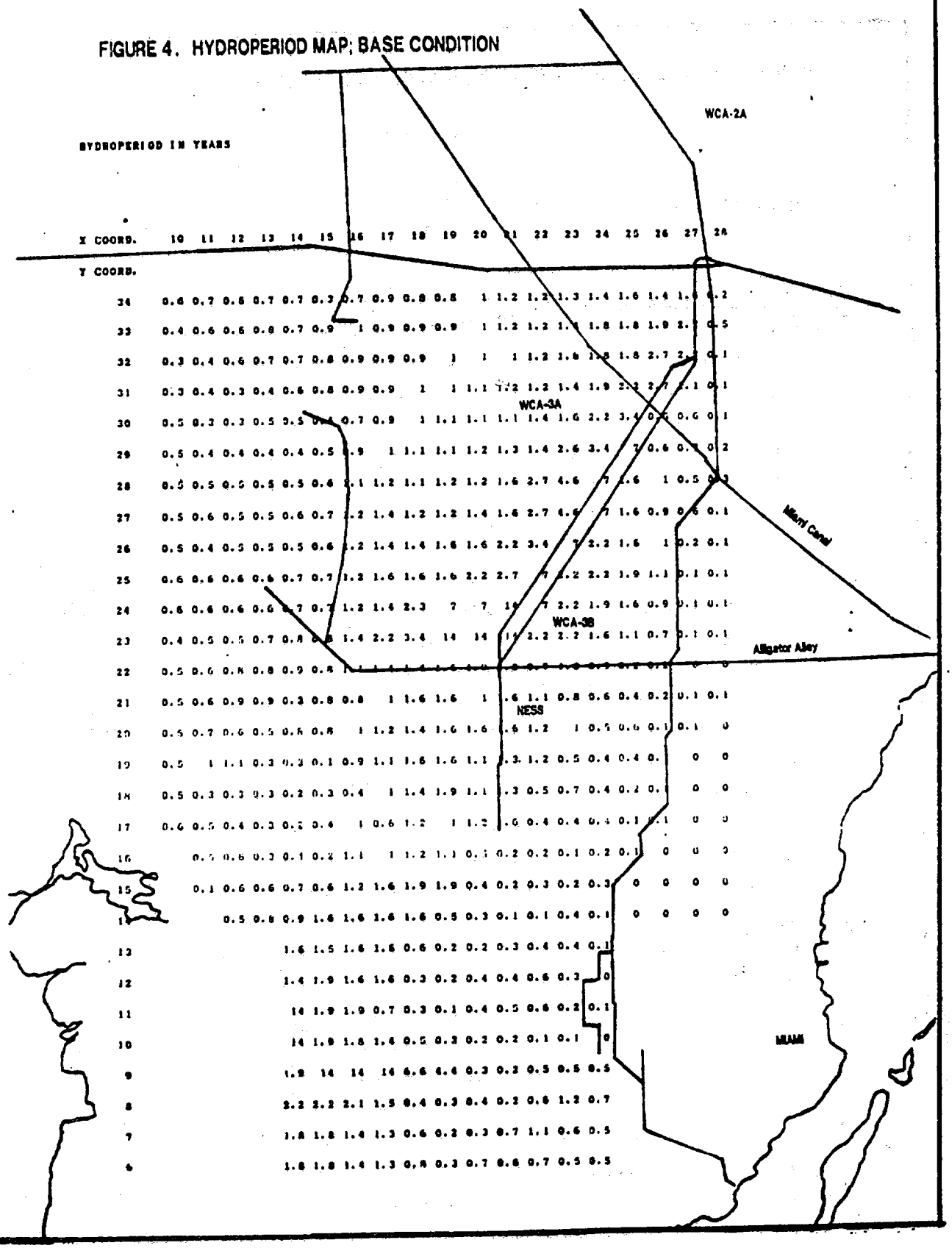


FIGURE 5. HYDROPERIOD MAP; MODIFIED MINIMUM DELIVERY ALTERNATIVE

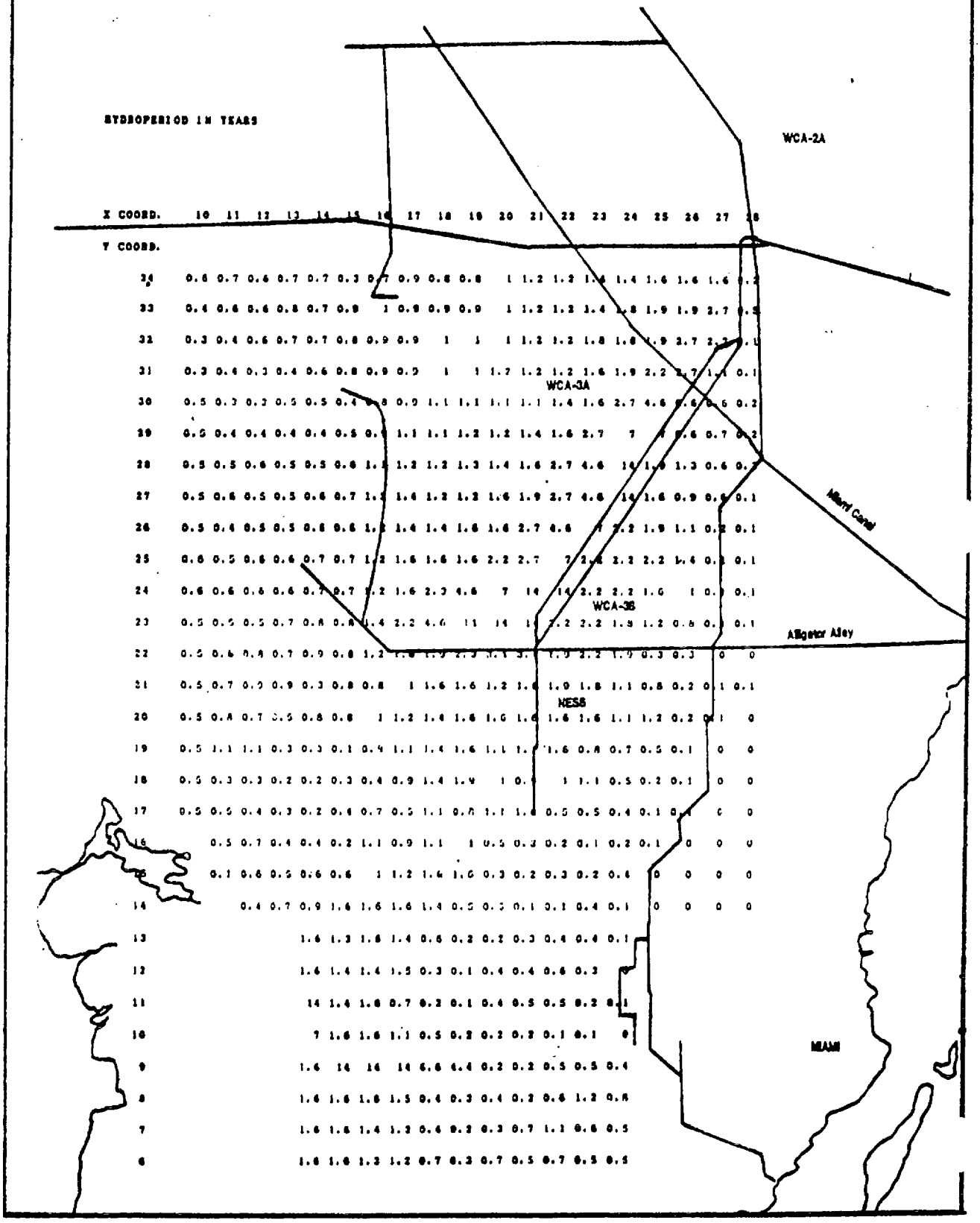


FIGURE 6. HYDROPERIOD MAP; BASIC RAINDRIVEN ALTERNATIVE

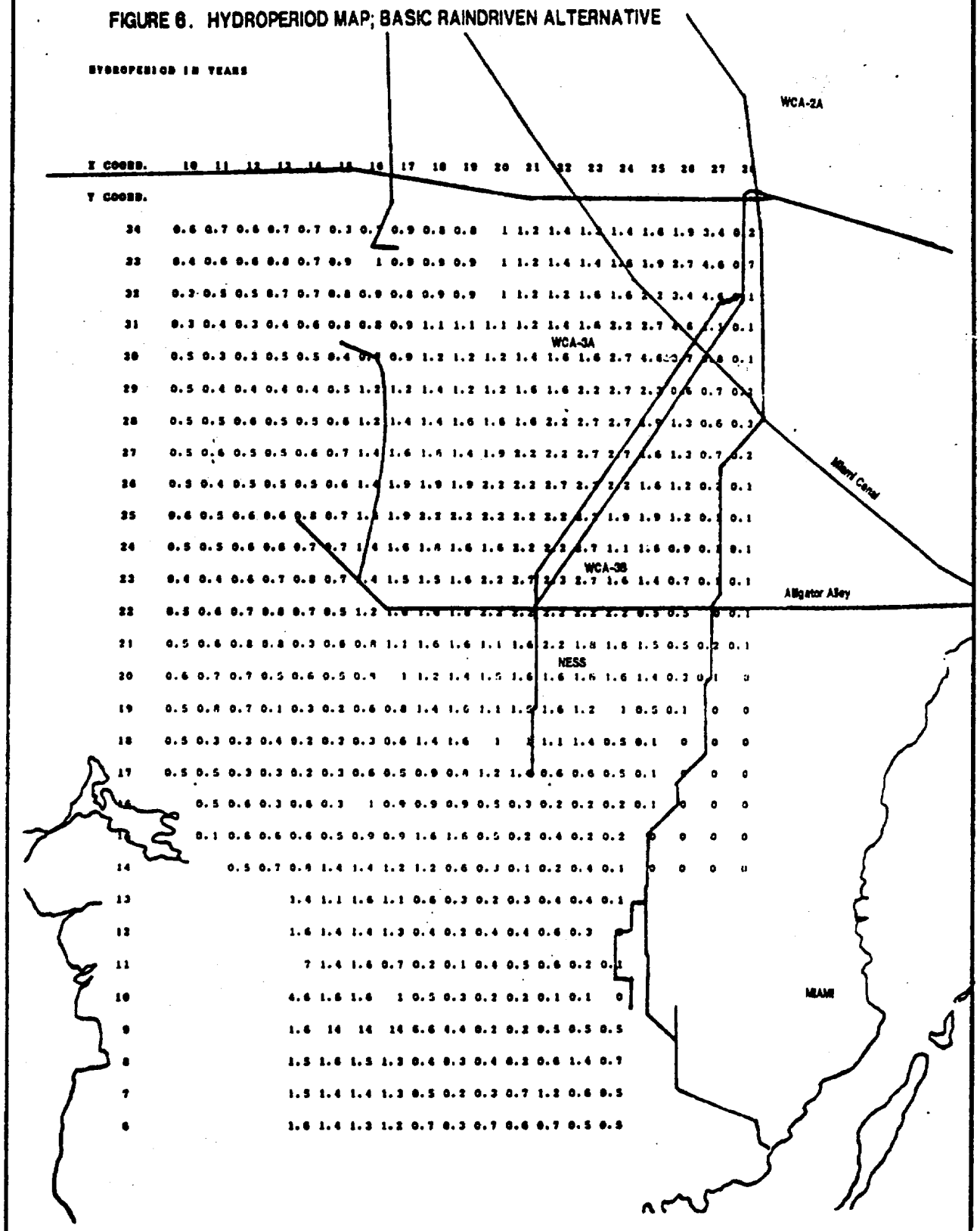


FIGURE 7. HYDROPERIOD MAP: MODIFIED RAINDRIVEN ALTERNATIVE

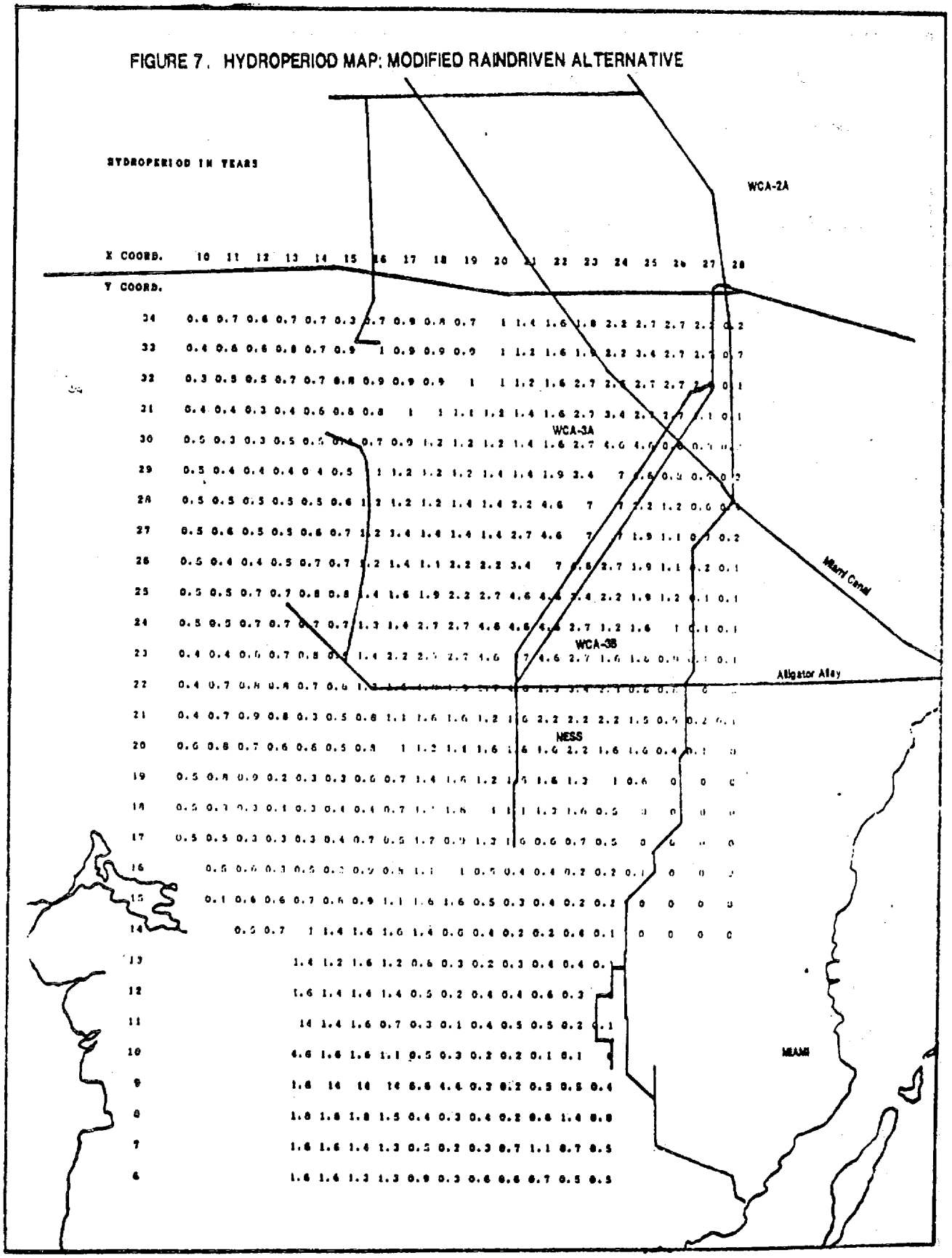
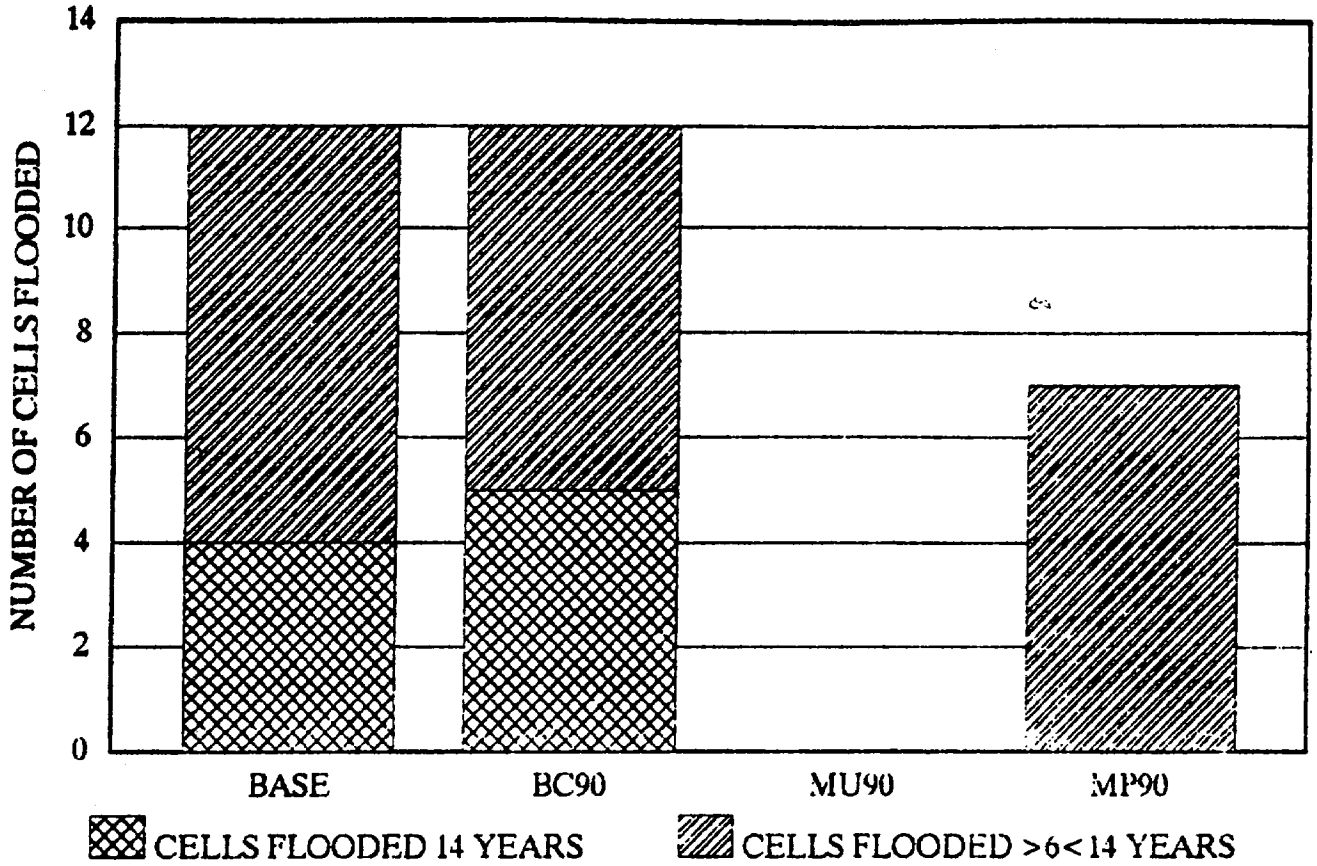


FIGURE 8. AVAILABILITY OF DROUGHT REFUGIA FOR WILDLIFE
ALTERNATIVE WATER DELIVERIES



EACH CELL 4 SQUARE MILES
WCA3A AND WCA3B

MODIFIED MINIMUM (BC90)

BASIC RAINDRIVEN (MU90)

MODIFIED RAINDRIVEN (MP90)

to the north and west. Fortunately, the stages at gauge 3-28 are significantly correlated with the number of cells that are flooded under historic conditions ($r=.928$, $P<.01$). Therefore, this relationship allows us to build on the findings of Takekawa and Beissinger (1989), and estimate the number of drought sightings that would occur under the four alternatives, without the above-mentioned bias. The steps in this process are: (1) using the relation between the number of cells flooded and the historic gauge 3-28 stages, identify the number of cells flooded and number of kite sightings at the listed intervals during the 1985 drought (Takekawa and Beissinger 1989). This allows one to relate the number of cells flooded to the extent of kite dispersal, and (2) using this relationship, determine the level of kite dispersal for each project alternative, based on the number of cells flooded during each year.

Figure 9 snows the degree of kite dispersal anticipated for the four alternatives, for each of the 14 years of the analysis. The maximum or worst case dispersal is a "1.0," while a "0" is the most satisfactory condition, permitting full use of the nesting habitat. Compared to the Base, the Modified Minimum is more advantageous to the kite in 9 of 14 years, and equal in the other 5. The Basic Raindriven is poorer than the Base in 5 years, better in 4, and even in 5. The Modified Raindriven is poorer in 3 and better in 6. During the dryer years, when all plans would have had dispersal (1971, 1973-75, 1982), the Basic Raindriven was most severe. The reader should remember that this is a reflection of tendency to disperse. The question of <u>where</u> the kites can disperse to is addressed in the next figure.

Figure 10a plots the number of cells remaining flooded over the entire year for each alternative. Note that in 1973 and 1974 birds would have been entirely dispersed under the Basic Raindriven and had no refugia in the Conservation Areas. In contrast, for those years in which dispersal under the Base would have exceeded the Basic Raindriven, refugia cells still were available to cushion the impact. The 1973 drought dispersal under the Modified Raindriven also would have left the kite without refugia in the Water Conservation Areas. The continuing loss of drought refugia outside the Conservation Areas (Takekawa and Beissinger 1989) increases our concern over this trend.

<u>Findings: in relation to the Recovery Plan</u>

The Snail Kite Recovery Plan (revised, 1986) states its goal as maintenance of a reproductively viable population in the face of 3-4 years of successive droughts, with no reproduction and high mortality. Further, "It is unlikely that delisting could be achieved due to the continuing loss of drought related habitats upon which Florida snail kites depend for survival." Priority 1 recovery measures include: protecting colony sites, developing drought related habitat protection plans, managing wetlands for snail production, identifying and mapping drought-related habitats, identifying limiting factors, identifying ecological relationships.

Findings: current study

The evaluation of impacts from these water delivery alternatives must take into account cumulative effects from historical and pending actions. The range of the kite in Florida has been markedly reduced due to drainage practices. Increased flood control and water consumption have reduced hydroperiod. In recent years, kites have abandoned Loxahatchee refuge and Water Conservation Area 2A. In both cases, loss of kite use was correlated with reduction in duration of flooding. Moreover, the proportion of the overall United States snail kite population which uses WCA3A appears to have declined since the onset of the experimental water delivery program in 1983 (Figure 10b). This observation obviously is of some concern, given the significant role played by WCA3A in prior years. In the face of increasing water demands (e.g., a large new wellfield has been proposed in Dade County, next to WCA3A) and proposed changes in Lake Okeechobee's schedule, the kite (and other wildlife) is being hard pressed to survive the typical wet and dry cycles experienced in south Florida. Thus we are concerned about the implications of water demands regarding the hydrology of WCA3A. The Surface Water Model depicted conditions for the 1990 demands and supply. Future increases in demand will cumulatively degrade kite habitat, if water use restrictions are not imposed to conserve the 1990 conditions.

Additionally, we are compelled to be cautious in accepting the hydrologic analyses. All modeling efforts include uncertainties and errors which increase the risk involved in using them to make decisions. As stewards of endangered species we must lean towards measures which tend to protect and restore their habitats and populations. In the current case, the habitat involved supports up to 90 percent of the United States population of kites, and so the importance of its protection is correspondingly high.

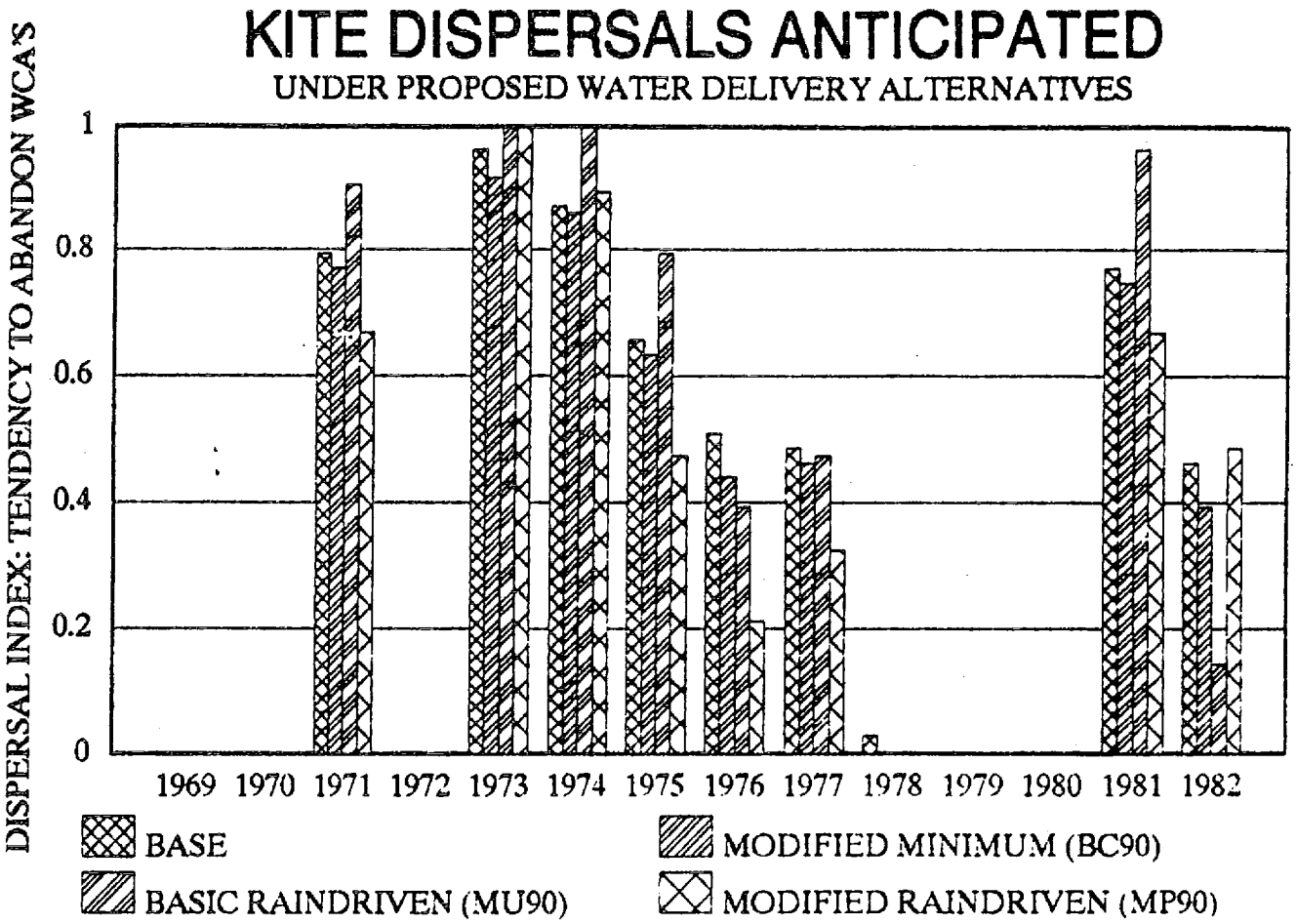
Modified Minimum Delivery

It is apparent that this alternative would actually be beneficial to the kite. Under this plan the frequency of drought-induced dispersal is significantly reduced (based on number of cells remaining flooded), and the availability of refuge habitat is improved. That is, 4 square miles more would have remained flooded even in severe drought. Therefore, this plan is not likely to jeopardize the continued existence of the snail kite or adversely affect Critical Habitat.

Modified Raindriven Plan

This alternative would be somewhat adverse to the kite. The frequency of drought dispersal may be reduced, but severe drought would eliminate all refuge habitat in the Water Conservation Areas. These impacts alone are not felt to be enough to jeopardize the continued existence of this species. However, the cumulative effect of this plan and reduction of habitat value in the remainder of the kite's habitat could lead to extinction. For this reason, water managers should be made aware that any future demands on water supplies are increasingly likely to "tip the

FIGURE 9.



BASED ON TAKEKAWA AND BEISSINGER 1989
SEE TEXT FOR DERIVATION OF INDEX

FIGURE 10a NUMBER OF CELLS REMAINING FLOODED ENTIRE YEAR
WATER CONSERVATION AREAS 3A AND 3B

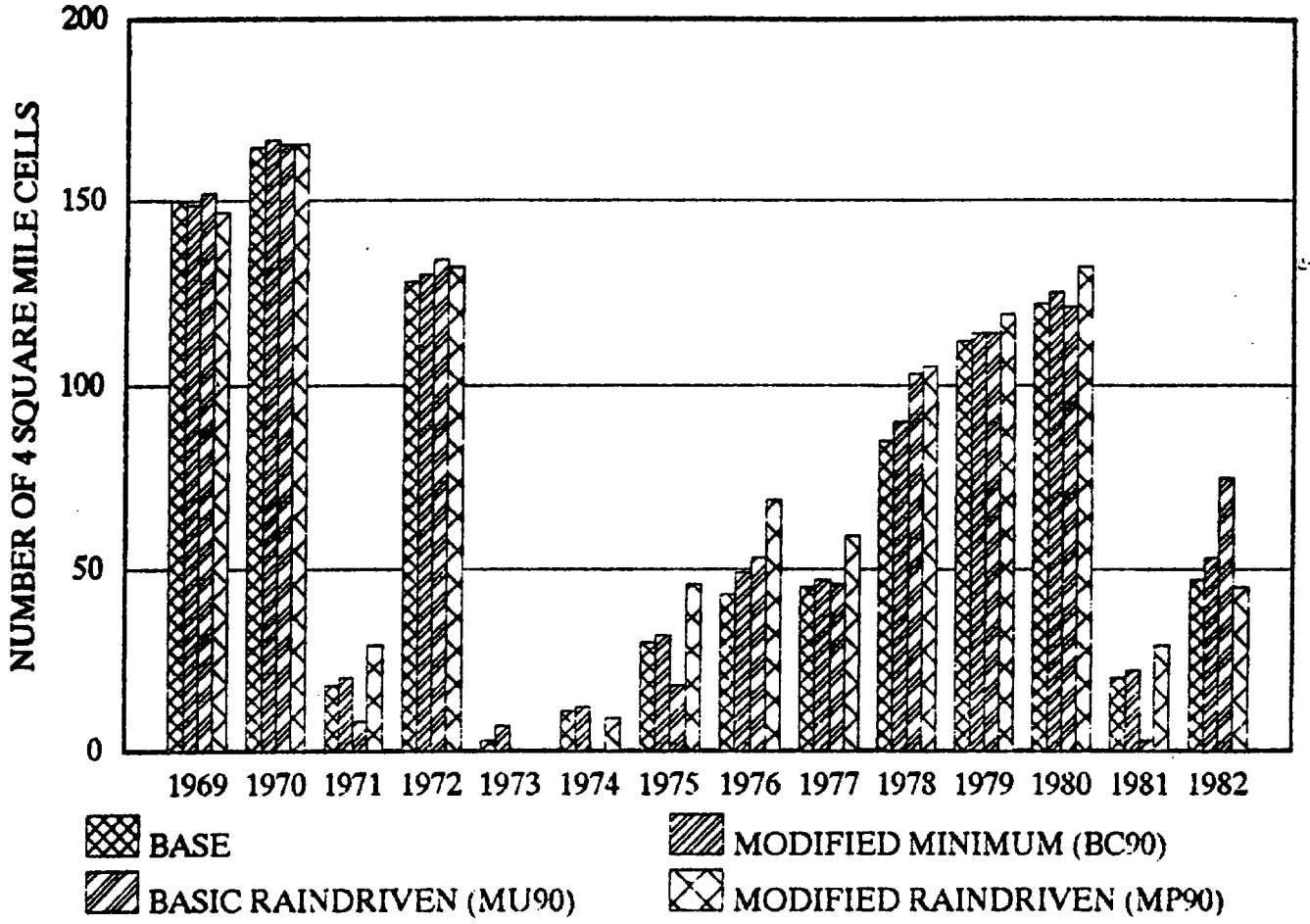
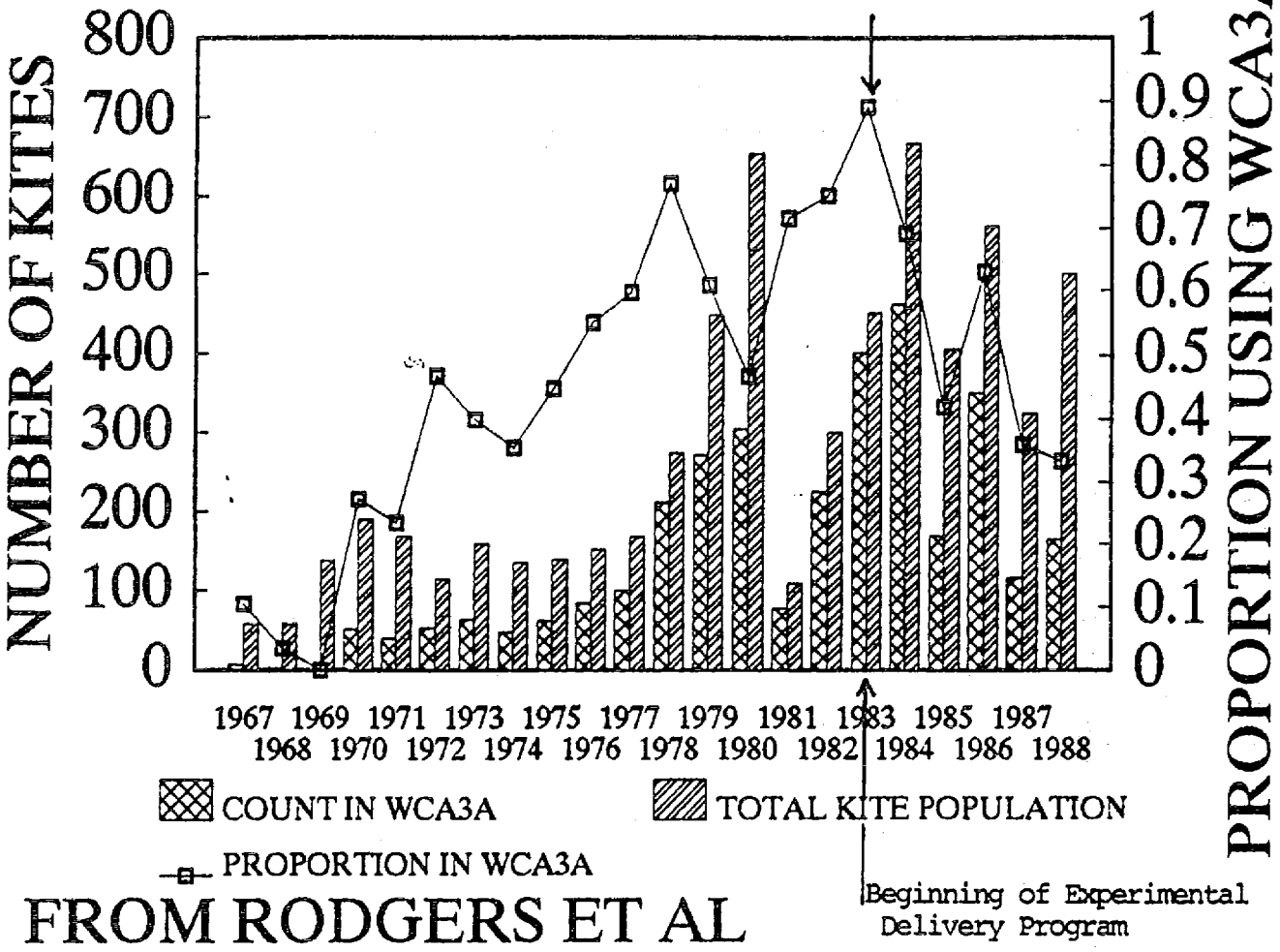


FIGURE 10b. NUMBERS OF KITES AND PROPORTION USING WCA3A



FROM RODGERS ET AL

balance" and result in a finding of jeopardy. Because this plan is likely to cause an increase in death of kites during drought events, it would require authorization of this incidental take. In order to insure that the effects of this alternative have been assessed correctly, this authorization is contingent on implementation of a monitoring program (described below). Therefore, this plan is not likely to jeopardize the continued existence of the snail kite or adversely affect Critical Habitat.

Basic Raindriven Plan

This Plan would eliminate all persistent habitat for the kite in WCA3A and WCA3B. It also would increase the frequency of drought dispersal from these areas. These changes would be significantly adverse based on the observations and conclusions of Bennetts, et al. (1988), and the commentary by kite experts Paul Sykes, James Rodgers III and Steven Beissinger. The opinions of the latter two were in writing and are appended. Sykes stated that WCA3A is the "key" to maintenance of the kite. Most of the remainder of the birds use Lake Okeechobee which experiences greater habitat fluctuations and loss of nests. Sykes felt that reduced hydroperiod in WCA3A would cause "real problems," and that the lowest point for the kite population was prior to impoundment of the Water Conservation Areas.

On the basis of these analyses, aggregate effects from prior wetland alteration, and expert opinion, the Service concludes that the Basic Raindriven alternative would jeopardize the continued existence of the snail kite and would adversely modify its Critical Habitat.

REASONABLE AND PRUDENT ALTERNATIVES

Provided below are reasonable and prudent alternatives that, if implemented, would not violate Section 7(a)(2) of the Act and would allow the objectives of the proposed water delivery system to the Park to be met.

1. Implement the Modified Minimum Delivery alternative described above.

2. Implement the Modified Raindriven alternative, with the monitoring program required to satisfy Section 7(b)(4) of the Act (see Incidental Take Statement, below).

Adverse modification of Critical Habitat can be avoided by implementing either the Modified Minimum Delivery alternative, or the Modified Raindriven alternative with monitoring.

INCIDENTAL TAKE

Section 7(b)(4) of the Act requires that when a proposed agency action is found to be consistent with Section 7(b)(2) of the Act, and the proposed action is likely to result in the take of some individuals of the listed species incidental to the action, the Service will issue a statement that specifies the impact (amount or extent) of such incidental taking. It also states that reasonable and prudent measures, coupled with terms and conditions to implement these measures, be provided to minimize such impacts. The Service must also specify procedures to be used to handle or dispose of any individual specimens taken. Reasonable and prudent measures are requirements of the action agency.

We have reviewed the biological information and other available information relevant to these alternatives. It is apparent that drought events cause snail kites to disperse from primary habitats, such as WCA3A. These dispersals result in extraordinarily low recruitment and higher mortality due to starvation, shooting and accidents (Beissinger 1986). Based upon our review, "incidental take" of the snail kite is not authorized during the implementation of the Modified Minimum Delivery plan, since this plan would actually tend to reduce drought dispersal.

The Modified Raindriven Plan may alter habitat in Water Conservation Areas 3A and 3B, which may result in the loss of snail kites during drought-induced dispersals. Incidental take of snail kites abandoning WCA3A is authorized under this alternative. The following reasonable and prudent measures provide information to minimize impacts to the kite population. Imposition of a threshold for corrective action (condition 2, below) and maintenance of refuge habitat (condition 3, below) will insure that the level of incidental take should not exceed estimates made for this Modified Raindriven alternative.

REASONABLE AND PRUDENT MEASURES

The Corps and South Florida Water Management District (District) will implement a monitoring program, develop a threshold for corrective actions, and establish the water supply management conditions for WCA3A so that future supply and demand does not shorten hydroperiod beyond that projected by the Modified Raindriven (MP90) model run. These will insure that habitat losses and changes in kite populations will not exceed estimates leading to a "non-jeopardy" determination. The monitoring programs, threshold for corrective actions, and maintenance of the refuge habitat all are features of this project which must be guaranteed by the District. Monitoring shall be funded for a period of at least 10 years, as called for in Terms and Conditions (2), below, in order to identify trends within the highly variable occurrence of the species in WCA3A. The Service's Vero Beach Field Office shall be informed of monitoring results on an annual basis. The threshold, the corrective actions, and water supply and withdrawal limits shall be identified prior to actual operation of the new structures.

Terms and Conditions

1. Monitoring information must include: (A) comparison of observed stages at gauges 3-28 and 3-4 to records of recent conditions (e.g., for the period 1977-1987); (B) examination of the continued use of the habitat by the kite; and, (C) banding and telemetry studies to improve our understanding of kite behavior and demography. Counts must be made of the numbers of snail kites utilizing Critical Habitat on a monthly basis during the peak of the breeding season, including an examination of whether snail kites are nesting or just foraging at these times. Banding and radio-tracking can help identify population trends, migration patterns, and heavily utilized nesting and drought habitats.

2. The Corps, in cooperation with the District, shall convene a panel of recognized snail kite experts and concerned State and Federal agency representatives for the purpose of defining the monitoring program. This panel will identify a "threshold" to trigger corrective action, should this monitoring identify unexpectedly severe impacts on the snail kite population. If kite use of WCA3A or WCA3B declines for 2 or more years in a row, or if banding and telemetry studies project an increased probability of extinction, the Corps must meet with the Service for a determination of whether the consultation process should be reinitiated.

3. The Corps in cooperation with the District shall take action to insure that the extent and quality of long-hydroperiod wetland in southern WCA3A shall not decrease below that identified under the Modified Raindriven Plan (model run MP90) as a result of increased water withdrawals or reduced supplies. Long-hydroperiod wetlands are identified as those Surface Water Model grid cells which dried no more frequently than once in the 14-year period of the Model run. This provision may be met by implementing just those water management measures and restrictions used in the MP90 model run. The Corps shall provide the Service's Vero Beach Field Office with a description of operating conditions and actions to implement this measure, highlighting and justifying any departures from the conditions used in that model run which might result in more frequent drying of WCA3A. These conditions and actions, once approved by the Service, shall become part of the binding Terms and Conditions for Incidental Take under this Biological Opinion.

If dead snail kites are found, the Vero Beach Field Office should be contacted immediately (407/562-3909).

Wood Stork

The wood stork is an endangered wading bird, once common in Florida. Breeding colonies in the southern half of the State have experienced a steady decline, most of which is attributed to habitat degradation. Hydrology is perhaps the key factor controlling habitat quality for the stork. The water delivery project, therefore, has the potential for recovering or for imposing further stress on this species.

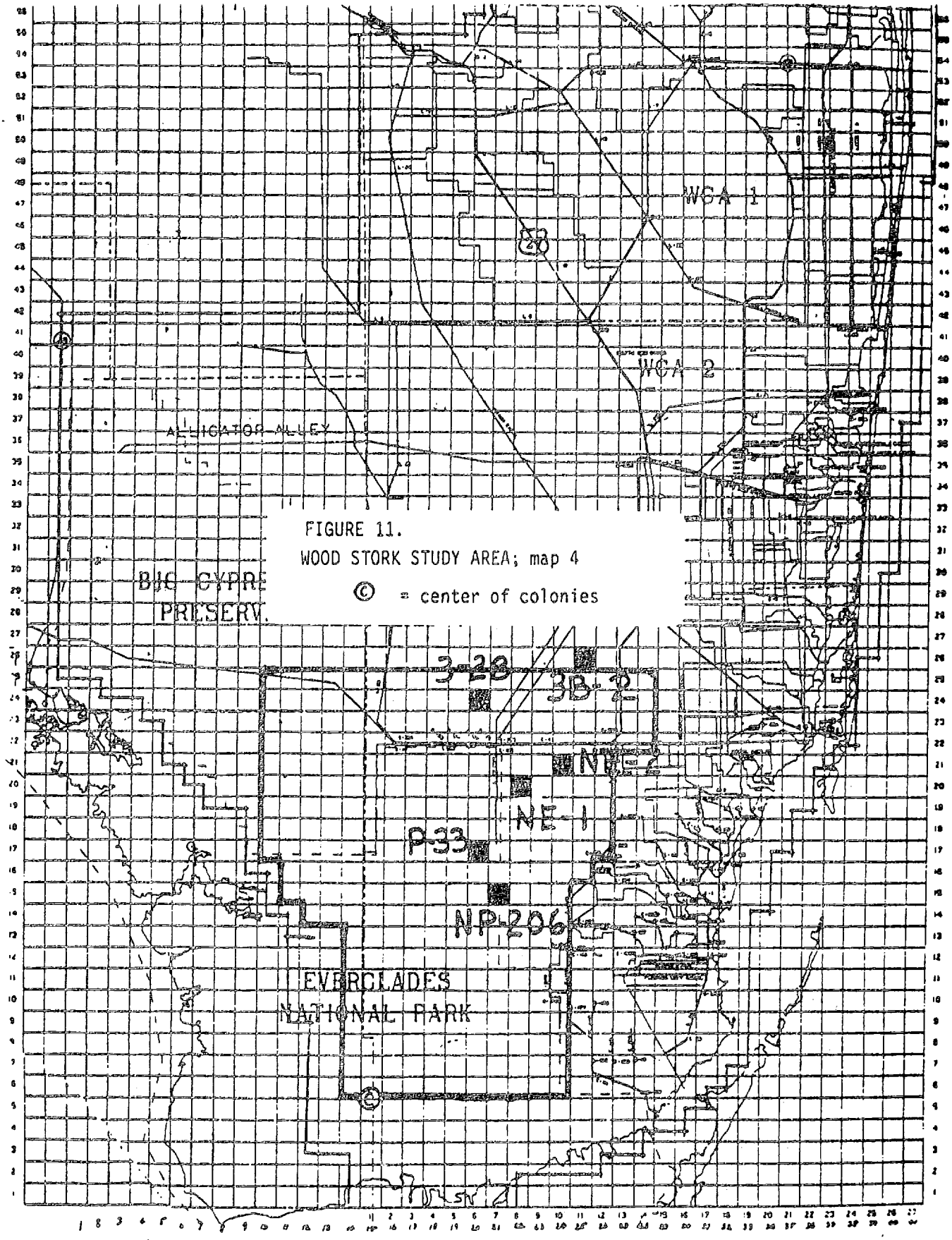


FIGURE 11.
WOOD STORK STUDY AREA; map 4
© = center of colonies

Green numbers are used in the expanded model. Squares with green lines are outside of the model.

The area included in the habitat analysis for the stork was that potentially affected by the four proposed alternatives and used by storks residing in the Park. Because the wood stork has a daily foraging range of over 50 km, the area examined for this Biological Opinion was drawn to encompass 1,200 square miles of wetlands around the major colony sites at East and Lane Rivers, Cuthbert Lake, and Madeira Bay, all at the southern tip of Florida (Figure 11). According to John Ogden (pers. comm.), these birds forage as far north as WCA3A, which defined the northern boundary of the study area. The eastern, western, and southern boundaries were set by the coverage of the Surface Water Model.

The assessment of impacts was based on an analysis of hydrologic data for the four alternatives, using a habitat model for the wood stork (Appendix A). This model is based on a relationship between two measures of habitat value (rate of production of fledgling birds per nest, number of pairs attempting nesting) and extent of the study area drying over 4 months of the reproductive season. This relationship was indexed on a 0 to 1.0 scale (Figure 12), to allow calculation of the relative habitat value for each alternative, by year.

Results of the analysis are presented in two forms. The first is a sequence of four tables (Tables 2,3,4,5) showing the proportion of the study area drying in four 2-month intervals for each year, for each of the alternatives. The tables also show the resulting habitat suitability values computed for each year. The second format is a graphic display (Figure 13) of the average annual habitat suitability for each of the alternatives, derived from the tabulated data.

Findings: in relation to the Recovery Plan

The Wood Stork Recovery Plan (1986) estimated the historic population at about 60,000 storks, which dropped to approximately 9,000 in 1975. Since that time the population has been fairly stable, although birds apparently have abandoned colony sites in south Florida and moved northward. Moreover, breeding success in the southern colonies has declined dramatically due to the reduction in food base. This is related to "decrease in areas subject to natural flooding followed by gradual drying; such a regime is essential to wood storks." The recovery objective for delisting is a self sustaining population of 10,000 pairs; the objective for reclassifying to threatened status is maintenance of 6,000 pairs (approximately 9,000 adult and immature birds). Among the Priority 1 recovery measures are determining feeding areas and implementing favorable water management.

Findings: current study

In comparing the four alternatives to the Base, we find that the Modified Minimum Delivery offers a 16 percent improvement in habitat value. On the

TABLE 2. BASE CONDITION
PROPORTIONS OF WOOD STORK STUDY AREA DRYING AFTER 2 MONTHS OR MORE OF FLOODING, AND RESULTING SUITABILITY INDEX VALUE

NESTING YEAR	NOV-DEC	JAN-FEB	DRYING MAR-APR	MAY-JUN	MAXIMUM OF 4 MOS.	INDEX VALUE
1970	0.08	0.08	0.12	0.02	0.20	0.00
1971	0.19	0.18	0.34	0.00	0.52	0.63
1972	0.08	0.11	0.22	0.00	0.33	0.00
1973	0.09	0.13	0.38	0.09	0.50	0.42
1974	0.12	0.26	0.32	0.00	0.58	1.00
1975	0.09	0.20	0.35	0.00	0.56	0.97
1976	0.26	0.11	0.29	0.00	0.40	0.00
1977	0.11	0.14	0.41	0.01	0.55	0.86
1978	0.05	0.01	0.23	0.02	0.25	0.00
1979	0.12	0.22	0.18	0.03	0.40	0.00
1980	0.07	0.12	0.11	0.03	0.23	0.00
1981	0.00	0.14	0.36	0.05	0.50	0.38
1982	0.22	0.17	0.04	0.00	0.38	0.00
					AVERAGE =	0.328

TABLE 3. MODIFIED MINIMUM DELIVERY
PROPORTIONS OF WOOD STORK STUDY AREA DRYING AFTER 2 MONTHS OR MORE OF FLOODING, AND RESULTING SUITABILITY INDEX VALUE

NESTING YEAR	NOV-DEC	JAN-FEB	DRYING MAR-APR	MAY-JUN	MAXIMUM OF 4 MOS.	INDEX VALUE
1970	0.07	0.07	0.10	0.02	0.17	0
1971	0.20	0.16	0.36	0.00	0.52	0.62
1972	0.07	0.10	0.24	0.00	0.34	0
1973	0.08	0.13	0.40	0.10	0.52	0.62
1974	0.12	0.22	0.37	0.01	0.59	1
1975	0.07	0.20	0.37	0.00	0.57	1
1976	0.25	0.10	0.33	0.00	0.43	0
1977	0.11	0.13	0.41	0.01	0.54	0.84
1978	0.04	0.01	0.24	0.03	0.26	0
1979	0.11	0.20	0.20	0.05	0.40	0
1980	0.07	0.11	0.08	0.02	0.20	0
1981	0.00	0.11	0.43	0.04	0.55	0.86
1982	0.21	0.16	0.05	0.00	0.36	0
					AVERAGE =	0.380

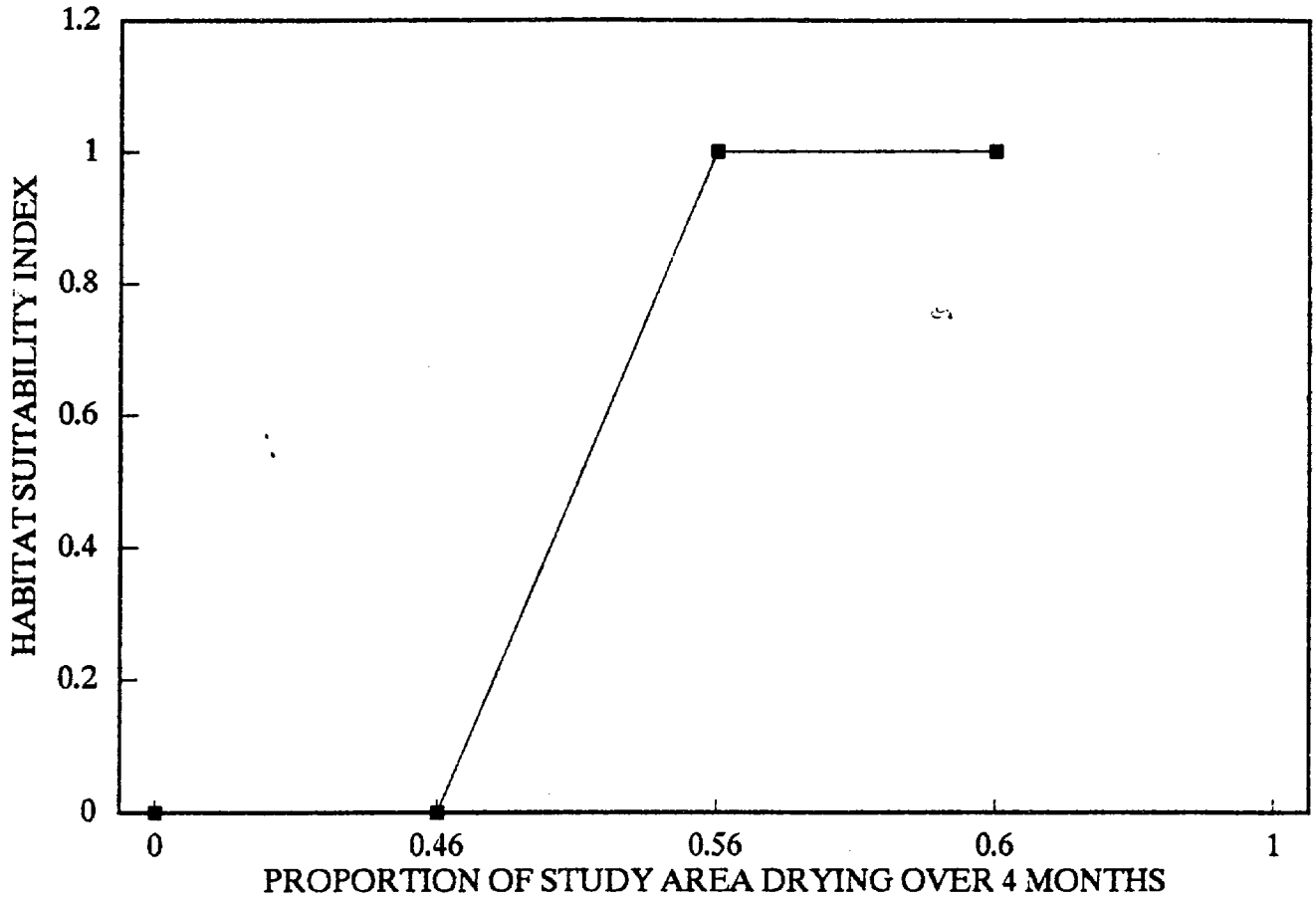
TABLE 4. BASIC RAINDRIVEN DELIVERY
PROPORTIONS OF WOOD STORK STUDY AREA DRYING AFTER 2 MONTHS OR MORE OF FLOODING, AND RESULTING SUITABILITY INDEX VALUE

NESTING YEAR	NOV-DEC	JAN-FEB	DRYING MAR-APR	MAY-JUN	MAXIMUM OF 4 MOS.	INDEX VALUE
1970	0.08	0.05	0.14	0.01	0.19	0
1971	0.21	0.26	0.31	0.01	0.56	1
1972	0.07	0.14	0.18	0.00	0.31	0
1973	0.10	0.15	0.30	0.16	0.46	0.04
1974	0.12	0.31	0.29	0.03	0.60	1
1975	0.09	0.23	0.38	0.00	0.61	1
1976	0.26	0.14	0.28	0.00	0.42	0
1977	0.13	0.17	0.35	0.01	0.52	0.62
1978	0.04	0.01	0.19	0.00	0.20	0
1979	0.12	0.24	0.16	0.01	0.40	0
1980	0.05	0.10	0.11	0.03	0.21	0
1981	0.01	0.15	0.32	0.09	0.47	0.11
1982	0.20	0.18	0.05	0.00	0.38	0
					AVERAGE =	0.290

TABLE 5. MODIFIED RAINDRIVEN DELIVERY
PROPORTIONS OF WOOD STORK STUDY AREA DRYING AFTER 2 MONTHS OR MORE OF FLOODING, AND RESULTING SUITABILITY INDEX VALUE

NESTING YEAR	NOV-DEC	JAN-FEB	DRYING MAR-APR	MAY-JUN	MAXIMUM OF 4 MOS.	INDEX VALUE
1970	0.05	0.03	0.11	0.01	0.14	0
1971	0.22	0.24	0.27	0.01	0.51	0.52
1972	0.06	0.13	0.19	0.00	0.32	0
1973	0.10	0.15	0.31	0.17	0.47	0.11
1974	0.12	0.29	0.33	0.03	0.62	1
1975	0.09	0.22	0.33	0.00	0.55	0.93
1976	0.25	0.14	0.27	0.00	0.41	0
1977	0.12	0.17	0.36	0.01	0.52	0.65
1978	0.05	0.02	0.18	0.00	0.21	0
1979	0.12	0.23	0.14	0.01	0.37	0
1980	0.04	0.11	0.08	0.01	0.19	0
1981	0.01	0.16	0.32	0.08	0.47	0.11
1982	0.19	0.18	0.05	0.00	0.37	0
					AVERAGE =	0.255

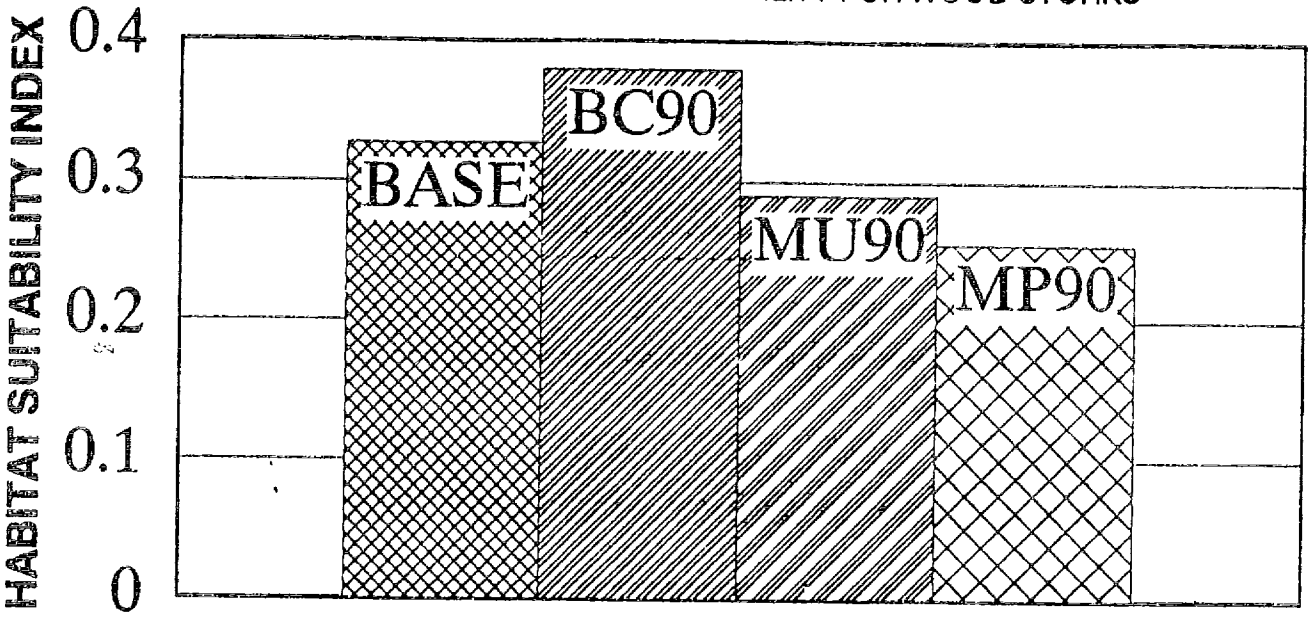
FIGURE 12. WOOD STORK MODEL



STUDY AREA = 1164 SQUARE MILES

D-96

FIGURE 13. HABITAT SUITABILITY FOR WOOD STORKS



WATER DELIVERY ALTERNATIVES

BASE

BASIC RAINDRIVEN

MODIFIED MINIMUM DELIV

MODIFIED RAINDRIVEN

ALTERNATIVES AS OF 11/7/89

BASED ON WOOD STORK NESTING SUCCESS MODEL

D-97

other hand, the Basic Raindriven Plan and the Modified Raindriven Plan both, reduce the extent of the study area drying over the critical period, and so degrade habitat suitability by 11 percent and by 22 percent, respectively, Considering the relatively small proportion of the United States population that nests in the Park, and the magnitude of the projected impacts, the effects of the four alternatives are not likely to jeopardize the continued existence of the wood stork. Therefore, the Reasonable and Prudent Alternatives for the snail kite also are satisfactory for the wood stork.

SUMMARY AND CONCLUSIONS

The United States snail kite population is highly dependent on habitat conditions in Water Conservation Areas 3A and 3B. Because of this, the widespread changes anticipated under the alternative water delivery scenarios have the capacity to greatly affect the kites' chances of survival.

1. The Modified Minimum Delivery alternative actually would enhance the designated Critical Habitat of the snail kite, and also improve reproductive conditions for the wood stork. Section 7(a)(1) of the Act states: "The Secretary shall review other programs administered by him and utilize such programs in furtherance of purposes of this Act. All other Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to Section 4 of this Act." For these reasons this plan should be the one preferred by the Federal action agency.

2. The Modified Raindriven alternative would reduce the value of the kites' designated Critical Habitat, inevitably resulting in greater losses of kites during severe drought events. Thus, it would require authorization for this incidental take. As reasonable and prudent measures, a monitoring program must be implemented to insure that this impact assessment is not an underestimate, and to allow for refinements in operation, in order to reduce effects on the kite. Also, a threshold for corrective actions and future water use restrictions must be defined in order to insure that cumulative effects from future development and water demand do not cause greater than anticipated loss of kites from drought events. This alternative would not jeopardize the continued existence of the snail kite.

   The Modified Raindriven alternative also would reduce the frequency and success of reproduction by the wood stork. However, considering the population size and distribution in the Southeast in comparison with the breeding population in the Park, we do not find that this level of effect would jeopardize the continued existence of the stork.

3. The Basic Raindriven alternative would increase the frequency of drought-induced dispersal of the kite from WCA3A and WCA3B. It also would eliminate much of the persistent habitat kites need in order to survive such events. For these reasons, this alternative is found to

jeopardize the continued existence of the snail kite, and to adversely affect its Critical Habitat. This alternative also would reduce the value of wood stork habitat in the project area.

This concludes consultation under Section 7 of the Act, as amended. If there are any modifications made in the project, or if additional information becomes available relating to threatened or endangered species, reinitiation of the consultation may be necessary. In analyzing impacts to the snail kite we have found that adequate hydrologic data is vital. If additional alternative water delivery plans are to be considered for the Everglades, we recommend that the action agency supply us this information (i.e, runs of the Surface Water Model) and allow us sufficient time for dealing with these complex issues.

Please notify us of your decision regarding the above reasonable and prudent alternatives. We will be pleased to assist you in developing measures to comply with our findings.

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APPENDIX A

A HABITAT SUITABILITY MODEL FOR THE WOOD STORK IN SOUTHERN FLORIDA

Arnold Banner (U.S. Fish and Wildlife Service, Vero Beach, FL 32961)

The Service has interest in the wood stork since it is both a federally listed endangered species and a bio-indicator of wetland conditions. Under the Endangered Species Act all Federal agencies have responsibility to avoid actions which would adversely affect the stork. The Service must go beyond this, seeking measures which should recover population and range. While the wood stork remains relatively widespread, south Florida's breeding colonies have dwindled. Therefore, this bird must receive attention when planning Federal projects, such as the modified water supply for Everglades National Park.

Under the Fish and Wildlife Coordination Act, the Service reports to Congress on the environmental effects from water resource projects. Key or indicator species may be used as sensitive measures of habitat changes or as representatives of feeding or reproductive guilds. The wood stork fits both criteria, further justifying attention during project planning.

Assessment of impacts to a species may be as simple as seeking expert opinion, or as involved as research and monitoring. As projects become larger and more complex, even experts have difficulty in dealing with resultant effects on a species. Moreover, the steps taken in arriving at an opinion are not likely to be well enough documented that outside reviewers can examine them stepwise, and modify the conclusions, if necessary.

As an alternative, the management action can be allowed to proceed and the actual physical and biological responses can be monitored. While the latter method is realistic, it requires the full commitment of expense and time, and potential risk to the affected resources. Also, alternative management actions cannot be tested synoptically in large scale systems, such as the Everglades, so species responses may not be attributable to the management action.

These two difficulties are avoided by use of species/habitat models. Such models can calculate the degree of change in a habitat's value as a function of key environmental variables, which are identified from studies of the species' biology. The models actually document the decision process, and they are inherently capable of dealing with the most complex management schemes. Modeling allows comparison of all alternatives in a quick, non-destructive manner. The process can identify limiting factors, and suggest actions to optimize conditions for the evaluation species. Probably the major limitation with habitat modeling is the quality of the model itself. That is, how well does the artificial constructed mimic the species? For this reason, models should be constructed from and their reliability must be tested against historic data documenting the use of its

habitat by the species. The wood stork model presented below has been developed in this manner. It builds on information derived from traditional field studies, but organized in a way to predict outcomes from different management schemes.

The works of wood stork researchers, including J. Ogden, J. Browder, J. Kushlan, and M. Coulter, served as guidance in model building. Reports and discussion by Ogden, in particular, allowed me to focus on the factors most critical to wood stork reproductive success in south Florida, and to compare historical water conditions with species responses. This has led to a fairly specialized model, suited to projecting impacts from hydrologic manipulations in the southern Everglades.

The decline of wood storks has been correlated with loss and deterioration of wetlands within range of historic colonies (Ogden 1985). Therefore, the study area included the home ranges of stork colonies at East and Lane Rivers, Cuthbert Lake, and Madeira Bay, all at the southern tip of Florida (Figure 11). According to J. Ogden (pers. comm.), these birds forage as far north as Water Conservation Area 3A, which defined the northern boundary of my study area.

This study area is drawn on a map of grid cells from the South Florida Water Management District's Surface Water Model. The Water Model computes stages throughout south Florida, on a daily basis, for a 14-year period of record. All types of management or structural changes can be superimposed on the historic conditions, and the model's output will depict their effects over those 14 years. One can compare the distribution and elevation of surface waters for any number of project alternatives, over both wet and dry years. The historical or validation run shows hydrologic conditions as they actually occurred, and these were the stages for which wood stork biology was analyzed.

I used the number of fledgling birds produced per nest as a measure of the suitability of the habitat. This measure is independent of the number of adult birds remaining from earlier years, and is sensitive to the ability of the habitat to support both parents and dependent young. Ideally, feeding conditions should peak at the time that young birds have greatest nutritional needs. This occurs in late winter/spring in south Florida, and later in north Florida and Georgia (Ogden 1985; Coulter 1986). Kahl (1964) noted that birds finished nesting in April/May, and Kushlan (1976) found that feeding in south Florida seasonal ponds peaked in April/May.

I also compared habitat conditions to the number of adults nesting, per year. This is less clearly related to habitat value, since it also responds to migration and to impacts from previous years. In both cases, it appeared that habitat value depends on availability of an adequate, accessible food supply which, in turn, is linked to hydrologic conditions within the stork's home range.

Biological data were available in terms of number of nesting adults and their relative reproductive success by year, where production of one or more fledglings per nest constituted success. Since this treated the entire colony as a unit, I examined the habitat suitability of the study

area as a unit also. That is, the wood stork requires a sufficient forage base for the entire reproductive period, and so the habitat value had to be considered by reproductive year. On the other hand, storks are highly mobile and visit different sites as water levels decline in the dry season, or with annual variation in rainfall (Ogden, 1985). Therefore, the value of each acre or grid cell must depend on the support value of the rest of the home range.

Following the lead of Ogden, I examined the importance of drying conditions during winter and spring. However, while Ogden found mixed results when comparing gauge records with biological responses, I used the actual area (number of 4 square mile grid cells) drying per unit time. Therefore, the hydrologic variable of interest was the extent of area drying during the reproductive season, by year.

The period of record of the hydrologic model was 1969 through 1982. This included just three years in which the number of young fledged exceeded one per nest. As a test of the stork model, and to extend the data set, I extrapolated hydrologic conditions for the years 1983 through 1986, and again compared the hydrologic variables to wood stork responses.

The extent of drying was expressed in terms of the maximum proportion of the study area drying over a 4-month period, for each year (Table 6). This value is the sum of the areas drying over 2-month increments, between November and June of each nesting year. A drying event was counted only if it ended at least 2 months of flooding. This helped insure that flooding events too short to build a forage base, and reversals of drying trends, were not accorded positive value.

Figure 14 compares these 4-month totals to the number of fledglings produced per nest. Note that the years having the highest proportions drying were those having successful reproduction by storks. This pattern also held for the 4 years of data extrapolated from the water model and gauge records.

I also compared the extent of drying to the number of storks nesting annually (Figure 15). The area drying was significantly correlated with this measure of reproductive effort ($r = .625$, $P<.05$). Thus a single, rather complex variable appears to be a reasonable predictor of both nesting effort and success.

To complete the habitat suitability model, I have indexed this variable on a 0 to 1.0 scale (Figure 12). The 0 point is set just below the minimum extent of drying at which reproduction was successful (0.46 of this study area) and the 1.0 or optimum condition was assigned to the proportion drying in 1975 (0.56), a highly successful year for the wood stork. The model is actually a spreadsheet program for use on a microcomputer. In evaluating benefits and impacts from water level manipulation the model is operated on hydrologic data for each of the 14 years, and the output values are compared to the no-action or baseline condition.

TABLE 6. PROPORTION OF THE WOOD STORK STUDY AREA (1164 SQ MI) DRYING AFTER 2 OR MONTHS OF FLOODING
HISTORIC HYDROLOGY, BASED ON VALIDATION RUN OF WATER MODEL

NESTING YEAR	NOV-DEC	JAN-FEB	MAR-APR	MAY-JUN	EXTENT DRY OVER 4 MOS.	S/F**
1970	0.09	0.07	0.17	0.02	0.23	F
1971	0.25	0.10	0.31	0.01	0.41	F
1972	0.09	0.13	0.23	0.00	0.35	F
1973	0.11	0.12	0.28	0.13	0.41	F
1974	0.16	0.24	0.25	0.05	0.50	S
1975	0.09	0.25	0.30	0.00	0.56	S
1976	0.26	0.13	0.25	0.00	0.39	F
1977	0.12	0.14	0.32	0.00	0.46	F
1978	0.06	0.01	0.12	0.00	0.13	F
1979	0.14	0.21	0.14	0.01	0.35	F
1980	0.09	0.10	0.10	0.02	0.20	F
1981	0.02	0.14	0.34	0.05	0.48	S
1982	0.25	0.14	0.05	0.00	0.38	F
CONTINUED, USING STAGES EXTRAPOLATED VIA GAUGE RECORDS						
1983	0.00	0.00	0.05	0.23	0.28	F
1984	0.07	0.12	0.23	0.01	0.35	F
1985	0.20	0.23	0.22	0.08	0.45	S
1986	0.13	0.19	0.03	0.07	0.32	F

** S= FEWER THAN 1.0 FLEDGLINGS PRODUCED/NEST
F= 1.0 OR MORE FLEDGLINGS PRODUCED PER NEST

FIGURE 14. DRYING CONDITIONS AND PRODUCTION OF FLEDGLINGS

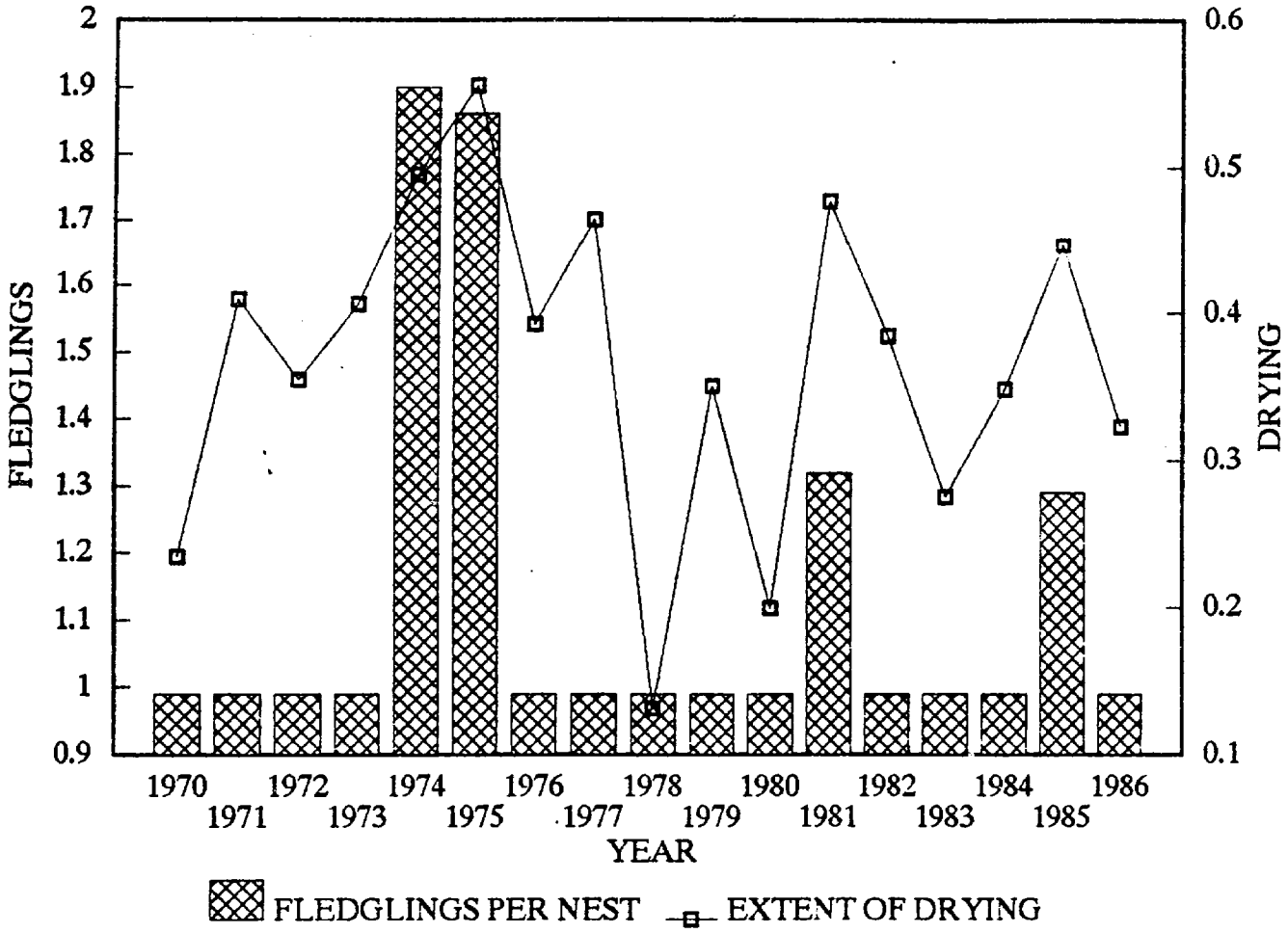

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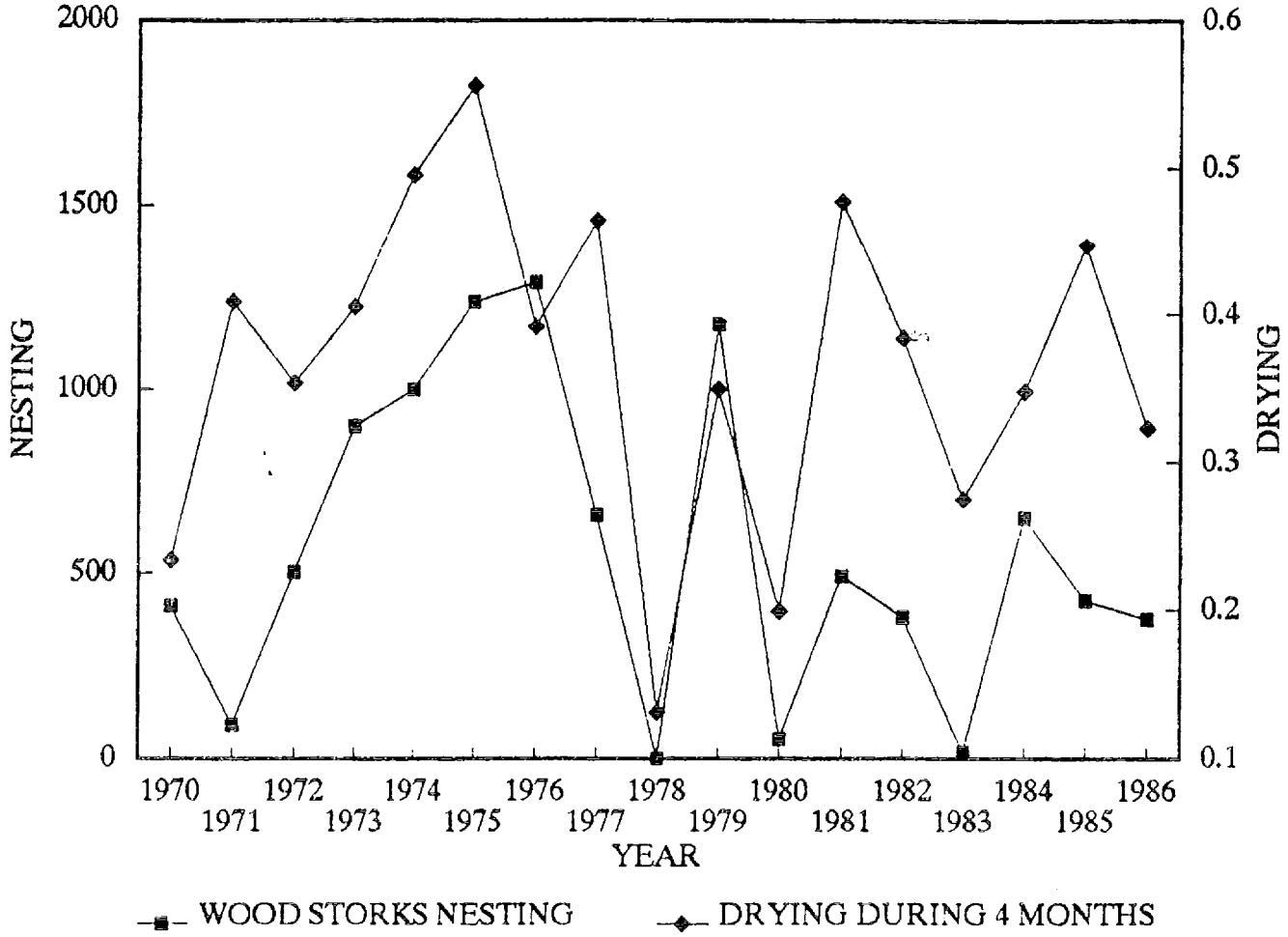
FIGURE 15. DRYING CONDITION AND WOOD STORK NESTING



D-107

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Yale University *New Haven, Connecticut 06511-2189*

SCHOOL OF FORESTRY AND ENVIRONMENTAL STUDIES

Sage Hall
205 Prospect Street

Telex: 5101012363 Yale FES

Arnold Banner, PhD.
Senior Staff Biologist
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, Florida 32961

JUN 08 1989

4 June 1989

Dear Arnold,

Thank you for the opportunity to comment on the importance of long hydroperiods for the security of the Florida Snail Kite population. I am in the process of analyzing the importance of rainfall and water levels on Snail Kite demography. Needless to say, I am attempting to ask the same question but in a different manner.

It is clear that the Florida kite population has been rising and falling cyclically in phase with Everglades water levels. That kite numbers have risen during the past 2 decades is probably due to the increased pool levels and more continuous flooding in State Water Conservation Area 3A (CA3A). Increased pool levels may lead to longer hydroperiods which, in turn, promote snail population growth and increase the number of years between drydowns. During drydowns, adult mortality may exceed 50% and no recruitment occurs. The effects of drydowns are also felt during the following year (lag year) as nesting productivity may decline.

Presently Everglades water levels have been rising and falling on a 4-5 year cycle (period between dryouts). This allows for 2 years of recovery between dryout events, assuming low lag year productivity. These two years of recovery have probably been responsible for the upward trend of cyclic growth of kite population during the past decade.

I believe that the long hydroperiod portions of CA3A are important to kite survival for several reasons. First, areas that remain more continuously flooded support survival and production of apple snails; in the remainder of CA3A snails must aestivate during drydowns, do not reproduce, and appear to suffer high mortality just prior to and during this period. After water levels rise, areas of long hydroperiod marsh in CA3A may provide a source of snails to colonize the remainder of the area. For example, I have enclosed a map of kite nests that I found in 1983 following the 1981-82 drought and the locations lie almost completely within the areas of your base condition map with long hydroperiods (4-14 years). Note also the analysis showing different reproductive success between these areas (see enclosure).

Second, long hydroperiod portions of CA3A appear to act as refugia for kites during drydowns. Before massive dispersal occurs, kites are first seen along the southern edge of CA3A and around the rim canal. Some birds probably remain in the remnant marsh until it is almost dry.

Yale University *New Haven, Connecticut 06511-2189*

SCHOOL OF FORESTRY AND
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If, as a result of changes in water management, hydroperiods are significantly shortened throughout CA3A, without the creation of large tracts of new habitat with long hydroperiods, I believe that it would be highly likely that kite populations will no longer continue to cycle upwards; instead they may reach either a stable limit cycle or begin a slow decline. I hope to have a better answer to this question by the end of the summer through the analyses that I am now undertaking.

If I may be of any further assistance in this manner, please do not hesitate to contact me. I will be gone for much of the summer but may be contacted at the following addresses:

10-19 June and 19-29 July:
c/o Whendee Silver Beissinger and Fred Scatena
Institute of Tropical Forestry
U.S. Agricultural Experiment Station
Call Box 25000
Rio Piedras, Puerto Rico 00928-2500
(809)766-5335

20 June - 18 July: c/o FPM
Apartado 39
Calabozo 2312-A
Guarico, Venezuela

(No telephone number but send a telegram to this address and I'll return will call within two days).

August - at Yale.

I would also be pleased if you could send me copies of your reports, especially on your HSI model, and other information pertinent to this problem. Please send them to my Yale address.

Sincerely,

Steven R. Beissinger
Assistant Professor of Wildlife Ecology

cc: Dave Wesley

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FLORIDA GAME AND FRESH WATER FISH COMMISSION

C. TOM RAINEY, D.V.M. Miami | WILLIAM G. BOSTICK, JR. Winter Haven | DON WRIGHT Orlando | THOMAS L. HIRES, SR. Lake Wales | MRS. GILBERT W. HUMPHREY Miccosukee

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July 11, 1989

JUL 13 1989

Dr. Arnold Banner
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961

Dear Arnold:

I am writing in response to your letter of 25 May regarding the rain driven water deliveries to the ENP and its effect on CA3A. If, as the ACOE model predicts and as drawn in the accompanying figures, the hydroperiod does decline from a 3-14 year average period between dry-outs to a 1-3 year average period between dry-outs, the impact could be severe on the Snail Kite. Whereas such a schedule may have little effect on predators of a highly mobile and colonizing prey base (i.e., wading birds on fish), severe and frequent dry-outs would continuously depress the Apple Snail population and ability to recolonize regions of CA3A.

Beginning in the early 1970's, Snail Kites began using CA3A and by the latter 1970's, this wetland possessed the highest number of kites (see Sykes and Rodgers generated census results). Drastic alteration of the hydroperiod has the potential to adversly effect the bulk of the kite population in Florida, especially since the ACOE has indicated a desire to alter the hydroperiod in Lake Okeechobee, the site of the second largest subpopulation of kites. Just the other day I was notified that the ACOE wants to carry out a similar procedure for CA2A.

At this point, it all seems confusing to a non-hydrologist. I only hope that if the long-term impact is negative, it will not be severe and can be reversed if detected early enough.

Sincerely,

James A. Rodgers

James A. Rodgers Jr., Ph.D.
Biological Scientist III

JAR/byc

cc addresses:

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Environmental Protection Agency
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National Marine Fisheries Service
Habitat Conservation Division
9450 Koger Boulevard
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Florida Game & Fresh Water Fish Comm.
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Tallahassee, FL 32304

Florida Game & Fresh Water Fish Comm.
110 43rd Avenue
Vero Beach, FL 32962

National Park Service
75 Spring Street, S.W., Room 1094
Atlanta, GA 30303

Everglades National Park
P.O. Box 279
Homestead, FL 33030

So. Florida Water Management District
P.O. Box 24680
West Palm Beach, FL 33416-4680

FWCA REPORT

APPENDIX B

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

Appendix B

HSI MODEL FOR THE SNAIL KITE

A. Banner and C. Sultzman
U.S. Fish and Wildlife Service

The snail kite is an endangered species largely as a result of its highly specialized diet (for which it was named). The abundance of its prey, apple snails, is closely linked to water regime (Kushlan 1975; Sykes 1979, 1983a). Drainage of Florida's interior wetlands has reduced the extent and quality of habitat for the snail and the raptor (Sykes 1983b). Also, the kite nests over water, and nests become accessible to predators in the event of unseasonal drying (Beissinger 1986; Sykes 1987c). This sensitivity to water conditions makes the kite an indicator of community stability. In dry years the kite depends on water bodies which normally are suboptimal for feeding, such as canals, impoundments, or small marsh areas, remote from regularly used sites (Beissinger and Takekawa 1983; Bennetts et al. 1988). These secondary or refuge habitats are vital to continued survival of this species in Florida.

GENERAL LIFE HISTORY

Though snail kites historically ranged throughout most of Florida (Sykes 1984) they currently utilize lakes and sloughs within the Kissimmee-Okeechobee-Everglades system, marshes and impoundments in the headwaters of the St. Johns River, and some outlying sloughs and wet prairies in the south-central part of the state. In the past 10 years population level has fluctuated widely (Sykes 1983a; Beissinger and Takekawa 1983; Beissinger 1986) in response to varying water levels in the Water Conservation Areas and in Lake Okeechobee.

Kites construct nests over water in snags, trees, shrubs or tall emergent vegetation (Sykes 1987a, 1987c; Bennetts et al. 1988). Nests are built of twigs and green vegetation, primarily between March and May. While rearing young, the adults forage no more than six km from the nest (Beissinger and Snyder, 1987), and generally less than a few hundred m (J. Rodgers, Jr., pers. comm.). At other times kites loosely aggregate at roosts (which often are used as nest sites; Sykes 1985), and range 1.5 - 2 km for feeding. Kites also are flexible about roosting substrate. They will roost in trees or shrubs over or near water, or on emergent vegetation, in range of an abundant food supply.

Kites locate prey by "coursing" and by still hunting (Sykes 1987b). In the former the bird surveys relatively large areas, diving and capturing prey sighted during flight, then alighting on a perch (which may be only emergent vegetation; Sykes 1987b) to remove the snail from its shell. In perch hunting the bird watches for snails from an elevated platform and swoops down, returning to that perch after an attempt at capture. Perches include snags, posts, or open trees, tall enough to offer visual advantage. Kites are not territorial about feeding habitat (Sykes 1987b).

Florida experiences drought episodes at a frequency of 5 to 10 years (Sykes 1983b; Beissinger 1986). In drought conditions kites will migrate to areas generally less preferred but still offering food supplies, even to urban situations (Beissinger and Takekawa 1983). While dispersal may be an effective response to local adversity, region-wide droughts cause precipitous declines in the kite population. Periodic drought and drainage of wetlands, with the attendant loss of the prey base, appear to be the overall limiting factor for kites in Florida (Beissinger 1986; Sykes 1987b). Therefore, this habitat suitability model assesses the potential value of an area both as breeding (or primary) habitat and as refuge or drought-related habitat. In each case the model takes into account the availability of the supplementary requisite.

ASSUMPTIONS/FACTORS

1. Minimum size. Habitat may be suitable for kites in terms of structure, but may simply be too small to maintain birds year round, or even during nesting. Such areas still can have value if they are within range of other habitat, and the combination exceeds the minimum needed to support kites. The smallest areas in which Sykes (1983b) found kites nesting were the Strazzulla and Cloud Lake reservoirs (Indian River County) and the Savannas (St. Lucie County). These are about 65, 240 and 250 hectares, respectively. Between 1972 and 1980 the Strazzulla reservoir supported an average of 2 kites, with a maximum of 7. While Cloud Lake held up to 13, it apparently was without kites several years during which the former was used. Therefore, it is assumed that a minimum habitat size to allow reproduction is met by 65 ha of productive slough, found within a radius of two km.

2. Abundance of prey. The supply of snails is related to frequency and duration of complete drying out of the water body, and presence of some emergent vegetation for egg laying (Snyder and Snyder 1971; Perry 1973) and as substrate for grazing. Submerged vegetation also offers cover and substrate for the snails (Beissinger et al. 1983).

Though they can aestivate in mud (Kushlan 1975), snails are abundant only where flooding occurs several years at a time (Beissinger 1983; Sykes 1983a, 1987b). Kushlan (1975) showed sharply lower concentrations of snails when drying events occurred as frequently as three years. Bennetts et al. (1988) found ample food supplies, allowing kites to successfully rear young, where frequency of drying was 1.6 to 3.8 years. On the other hand, they noted a 10 year lag between the impounding of Water Conservation Area 3a and heavy usage by kites. Apparently it took this long for kites to respond to an expanding snail population or perhaps for vegetative cover to become more open.

3. Accessibility of prey. Water depth is assumed to greatly affect the accessibility of the snails to kites. Sykes (1983b) stated that kites feed in .2 to 1 m depths. Snails are likely to aestivate when water drops lower, and are out of reach in greater depths.

4. Vegetation. Vegetative density also is critical to the kite's being able to reach snails. Relatively open conditions are essential (assumed to be 0-25% vegetative cover, Sykes 1987b), whether of emergent or floating vegetation. Sykes (1983b) suggests that the optimal configuration for kites includes 50-75% wet prairie and slough, 25-40% sawgrass, 5-15% tree island and willows, with good interspersion.

5. Prolonged flooding may benefit snails, but tends to eliminate perches, roosts and nest trees. Emergent sedges, trees and shrubs require periodic exposure at the root zone for their maintenance and for germination of seedlings (*cite*). Because of this Sykes (1983b) recommended that marshes managed for kites be dried and burned at 6 to 10 year intervals.

6. Drought refugia. The question of where kites feed when the primary marshes dry is crucial to the habitat evaluation model. During region-wide drought, the birds are forced to feed along canals, ditches, borrow pits and outlying lakes even hundreds of km away (Beissinger and Takekawa 1983). These refugia support enough birds to allow maintenance of the species in Florida. Refugia are essentially permanent water bodies with sizeable populations of apple snails, that are accessible for kite foraging during drought periods. They may be in fairly urban settings, and the kites may roost in trees adjacent to the feeding sites (Beissinger and Takekawa 1983).

7. Disturbance. The suitability of a site for roosting or nesting is reduced by intrusion of human activities. This includes temporary factors, such as the approach by vehicles, or permanent degradation of habitat from land development activities. Kites are less readily disturbed when just foraging (Beissinger et al. 1983), and so use of refuge habitat is less likely to be so affected.

MODEL STRUCTURE

Suitability index values (SI) are derived by comparing the physical conditions and configuration of a site to those preferred by that species. The individual SI values are combined into a single HSI (habitat suitability index) based on the way in which they are likely to affect the species, and the probable magnitude of the effect. The algorithms for weighing and combining SI values are based on empiracle and rational analysis of data (O'Neil et al. 1988). For example, stress factors can only degrade HSI, and so model output is multiplied by their SI values. Attributes which can compensate for other factors may be averaged; if they can substitute, then the maximum of the alternatives may be selected.

The snail kite model has two major sections. One computes suitability of a wetland as routine feeding, breeding or roosting habitat (fig. 1). The second calculates a sites' value as a refuge during drought (fig. 2). One factor, the frequency of drydown, appears to distinguish these two situations. Areas which dry out at less than six year intervals are likely to score highest as primary habitat. More permanent water bodies have higher value as refugia.

While the model takes into account the distance between the two types of habitat, other analyses (e.g., comparing amounts of primary to refuge habitat within a region) were not attempted, considering the present state of knowledge and the data-processing demands. Thus HSI is the higher of the values computed for an area by the two branches of the model.

VARIABLES

Water stages (V1, V2). Both depth and duration of flooding are critical to the kites' use of a wetland. A water depth ranging between .2 and 1 m is ideal for feeding (Sykes 1983b). This range also is preferred for sites in which the birds nest (Bennetts et al. 1988). The model relates suitability directly to the proportion of time a site is at this preferred depth (V1). Somewhat deeper conditions (1-2 m) are used on occasion (Beissinger pers. comm.) and so for breeding habitat time within this depth range (V2) is accorded half the suitability value of the former. The combined score for the two depth ranges (V1 + V2/2) is considered fully suitable (SI = 1.0) if it equals 0.8 or higher; a score of 0 is completely unsuitable.

In refuge habitat the deeper areas may encourage buildup of snail populations which become more available and essential during drought conditions. For this reason the two depth ranges are given equivalent scores in that branch of the model, and SI = 1.0 if the combined scores (V1 + V2) equals or exceeds 0.8.

Hydroperiod (V3). The frequency of drying may well be the most important measure of suitability for primary habitat. Bennetts et al. (1988) carefully analyzed the significance of this factor in kite's selection of nesting sites in Water Conservation Area 3A. Although they observed kites foraging over areas with shorter hydroperiods, kite nesting during 1986 and 1987 was restricted to areas which dried out between 1.9 and 3.8 years. They decided that the range of hydroperiods suitable for use by the kite was between about 1.6 and 5 years. This seems reasonable for reproductive use, but kites likely would have suitable feeding conditions with an even longer interval between drydowns. The nest location data from Bennetts et al. agrees with the 1.5 year minimum (see validation section, below) and so this model finds an average drying frequency (V3) of 1.5 years or less to be unsuitable (SI=0). Intervals of 3 years to 5 years are rated as fully suitable (SI= 1.0). Recognizing that prolonged flooding slowly eliminates emergent plants, suitability as primary habitat declines to 0.1 at 7 years and above.

The value of refuge habitat also is related to the frequency of drying events. Here, suitability is 0 at 4 years or less and 1.0 for hydroperiods of 8 years or more.

Interspersion of breeding and refuge habitats (V4, V5). In theory, one should determine whether the breeding or the refuge component is the limiting factor in order to correctly assign habitat value. However, this would require a comparison of their relative availabilities within a study area hundreds of km in radius. This approach may be feasible with more

extensive application of geographic information systems. The present model simply relies on the fact that the availability of each component is related to the radial distance one must travel to encompass a given extent of the habitat.

Sufficient refuge habitat should be accessible to birds using primary habitat. The availability of refugia is related to the extent of usable wetland (i.e., less than 2 m deep) within range of the primary habitat. The minimum primary habitat area for a pair of kites was assumed to be 65 ha (see assumptions/factors). It is assumed that birds would not be rearing young during drought, and might survive on a suboptimal food supply. On this basis, the minimum area for a complementary refuge habitat was taken as 30 ha. Since the snail kite is a good flier, and can travel hundreds of km in a severe drought, the optimum suitability value for this factor (V4) was determined to occur when the 30 ha was found within a radius of 6 km or less from the center of breeding habitat. The minimum SI was set at 0.1, at 100 km or more, to insure that even remote breeding habitat would be scored in accordance with its utility to the species. When addressing a permanently flooded wetland as refuge habitat, the corresponding interspersion factor is the distance which must be travelled to cover a total of 65 ha of breeding habitat. This value for refuge habitat (V5) is maximum when it is close to the primary habitat (SI = 1.0 at a radial distance of 3 km), and drops to an SI of 0.1 at 100 km.

Vegetative cover (V6, V7). Density of vegetation can restrict the ability of kites to capture snails. It is assumed that areas having 0-25% cover by emergent plants erect or floating, is fully suitable (Sykes 1987b), and that 26-50% cover (on a meter square basis) is half as good. More dense (> 50%) cover would only be of use for snail production and as roost or nest sites for the kites. The SI for vegetative cover is computed by adding the proportion of the area at 0-25% cover (V6), to half the proportion having 26-50% cover (V7) . The absence of such open marsh yields an index of 0; SI = 1.0 when the combined values equal 0.7 or above (allowing some patches of denser cover. This agrees well with the ratio from Sykes (1983b).

Perch/nest structure (V8). Still hunting is limited by availability of perches (Sykes 1987b). It is assumed that emergent vegetation is needed for perching, nesting and roosting in breeding habitat but that the birds will perch and roost in trees growing on land near the edge of permanent waters in refuge habitat. Nesting would not usually be attempted during drought conditions. Sykes observed kites to capture prey up to 12 m from perches. Therefore, I assume that the ideal spacing of perches is 25 m apart. Suitability of densely forested areas is 0, while the absence of perches lowers but does not eliminate habitat value. Measurement of the average distance between trees or counting the number of trees per unit area are poor sampling techniques because of typically patchy distribution. Instead, I use the average distance from random points within the area to the nearest tree or tall shrub (V8). This can readily be measured on aerial photos. The 25 m spacing between trees is equivalent to an average distance to the nearest perch of about 9 m. SI values for average distances of 1, 3, 9, 15, and 1000 m are 0, 1, 1, 0.6, and 0.1, respectively.

Disturbance (V9). While nesting or roosting, kites are sensitive to disturbance by humans. It is assumed that residential or commercial structures can readily be identified with this intrusion. If the study area lies within 0.5 km of residential or commercial structures it offers minimal value (SI = 0.1) as breeding habitat. An SI of 1.0 for this factor requires that all of the area lie beyond this distance. Disturbance is not considered a limiting factor for refuge purposes.

COMBINATION OF VARIABLES

In addition to rating suitability of individual variables, the model must combine them in a manner reflective of their relative significance to the species. The mathematic operation determines the weighting of the factors. In the breeding branch the availability of trees (V8) is not a very significant factor because kites can perch or nest on emergent vegetation, and feed by coursing. Therefore, this factor is multiplied by the square of the SI for cover (V6 and V7), and the cube root of the product is carried forward as the output.

On the other hand, straight multiplication of SI's is used with variables V3, V4, and V9. Combining them this way, especially near the output end of the branch, gives them great opportunity to adjust the HSI downward.

MODEL VALIDATION

The breeding branch of the kite model was validated by comparing its output to observed use of the evaluated habitat. HSI values were computed for 49 grid cells, each 4 sq mi in area, and related to the numbers of kite nests Bennetts et al. (1988) found in those cells (figure 2).

Data for the HSI analysis were developed from gauge records and isopleths produced by the Corps, depicting proportions of the time flooding was within 20 to 100 cm, 1 to 2 m, and the frequency of surface drying. The Corps figures were based on a 14 year period of record (1969-1982), and forecasted the base conditions and rain-driven scenarios related to the project. In order to calculate HSI's for the 1986 and 1987 nesting observations by Bennetts et al. (1988), we rescaled the isopleth values to reflect hydrologic conditions pertinent to that period.

The longest term record available to us was for gauge 3-28, and this was used as a reference to set the other stations. Frequency of drying at 3-28 between 1975 and 1987 was 2.6 years. Frequency of drying at the 3-4 station was set at 2.0, based its relationship to 3-28 from 1969 to 1975. Between 1980 and 1987 the observed interval was 1.9 years, verifying this approach. Accordingly, intervals were set at 0.91 for gauge 3-2 and 1.4 for gauge 3-3.

During 1986 and 1987 the depth ranged between 20 and 100 cm at gauge 3-28. Water was in this depth range 0.84 of the time at 3-4. For gauges 3-2 and 3-3, the time spent at 20 cm to 1 m was 0.36 and 0.74, respectively.

Using the above gauge values, the Corps' isopleths were redrawn to depict conditions in the 49 grid cells for 1986-87.

All vegetation variables were measured from aerial photographs. Large scale color infrared transparencies, taken in 1979, were used in measuring mean distances to individual shrub patches or trees. These were viewed at a scale of 1" = 100'. The aerials were displayed through a randomly placed transparent grid and the distances to the nearest tree or tall shrub were measured for 4 to 8 individual cells, each about 1 ha in area. These values were averaged to produced a single figure representing the subarea value. For those subareas where CIR photo coverage was lacking, a value from the closest similar site was substituted.

Vegetation densities within the subareas were measured from black and white transparencies of aerials taken in 1979. These were displayed at a scale of 1" = 0.5 km, and 4 to 8 plots, 4 sq km each, were sampled using a 100 dot grid. The relative abundance of four categories of signatures were counted: tree or shrub islands with the associated dense sawgrass (dark, textured image); sawgrass (uniform moderate intensity image); sparsely vegetated flats (brilliant white image, sometimes reticulated with inclusions of sparse sawgrass); sloughs (uniform dark signature with distinctive configuration). These data were interpreted in accordance with published accounts of plant coverage characteristic of those communities (Zaffke 1983, Schortemeyer 1980, Tanner et al. unpubl.).

Numbers of nests and model output showed a significant correlation, but nesting occurred only at locations with HSI values of 0.5 and over (figure 2). This gives the appearance of a "threshold" for nest site selection, with any conditions at or above some minimum being equally suitable. While habitat use normally would be expected to increase with increasing suitability, the model output may in fact be appropriate. Kites select a nest site over a short period of time during which conditions may not reflect long term habitat suitability. Also, the kite population may have been below carrying capacity of WCA-3A, and kites may have selected only the most attractive nest sites.

In summary, model output agreed with observed habitat use, and the areas with HSI of 0.5 or better appear to be suitable for nesting by kites.

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BREEDING BRANCH

```
(V2 X 0.5)-->--sum---graph---geometric---geometric---product-->--OUTPUT
                |               mean        mean          |
(V1)-->---------^                |            |           |
                                 |            |           |
           (V3)-->---graph------^            |           |
                                              |           |
(V6)-->--------sum---graph---weighted--------^           |
                |             geometric                   |
(V7 X 0.5)-->---^               mean                      |
                                 |                       |
           (V8)-->---graph------^     (V4)-->---graph---^
                                                         |
                                      (V9)-->---graph---^
```

HABITAT VARIABLES

V1: Proportion of year flooded 20 cm to 1 m deep.
V2: Proportion of year flooded 1 to 2 m deep.
V3: Mean number of years (or part of year) between total drydowns.
V4: Radius of circle centered on site needed to encompass total of 30 ha permanent wetlands, <= 2 m deep.
V6: Proportion of site with emergent vegetative cover 0 - 25%.
V7: Proportion of site with emergent vegetative cover 26 - 50%.
V8: Mean distance to nearest tree or shrub > 2 m tall.
V9: Proportion of site within 0.5 km of residential or commercial structures.

Figure 1. General structure and variables of the Snail Kite habitat model, breeding branch.

REFUGE BRANCH

```
(V2)-->--sum-----geometric-----geometric---product-->--OUTPUT
         |         mean           mean          |
(V1)-->---^          |              |            |
                     |              |            |
(V3)-->---graph------^              |            |
                                    |            |
(V6)-->--------sum---graph---------^            |
               |                                |
(V7 X 0.5)-->---^                                |
                                                 |
                        (V5)-->---graph-------^
```

HABITAT VARIABLES

V1: Proportion of year flooded 20 cm to 1 m deep.
V2: Proportion of year flooded 1 to 2 m deep.
V3: Mean number of years (or part of year) between total drydowns.
V5: Distance to nearest >= 65 ha wetlands, typically .2 - 1 m deep.
V6: Proportion of site with emergent vegetative cover 0 - 25%.
V7: Proportion of site with emergent vegetative cover 26 - 50%.

COMBINATION OF BRANCHES

```
BREEDING OUTPUT-->-----maximum---->-----HSI
                        |
REFUGE OUTPUT-->----------^
```

Figure 2. General structure and variables of the Snail Kite habitat model, refuge branch and combination.

Library: C:EVER.HLB
11-23-1988

Model # 7 Multi-covertype model.
Model name: SNAIL KITE 1.5a
Verification level: Author Draft
Creation/modification date: 9-8-1988

MINIMUM AREA FOR APPLICATION: Either 65 ha or more of FWWETL covertype within a 2 km radius or FWPERM covertype of any size.

Covertypes:
FWWETL : FRESHWATER (<5 PPT), TYPICAL DRYING INTERVAL .1 TO 6 YEARS
FWPERM :FRESHWATER (<5 PPT) ZONE OR DISCRETE, TYPICAL DRYING INTERVAL => 6 YRS

LIFE REQUISITE: BREED
Covertypes:
FWWETL

```
Lev 6     Lev 5     Lev 4     Lev 3     Lev 2     Lev 1
 DFL1/2---usf------grf------gem------usf------prd-LRSI
 DFL20/1---^                  |         |         |
           FRDRYSK--grf-------^         |         |
 BAREVEG--usf------grf------usf-------^         |
 LOMODVG---^                  |                  |
           ABTREES--grf-------^                  |
                              DPERMSK--grf-------|
                              DDEVEL---grf-------^
```

Habitat variables:
ABTREES :MEAN DIST. (M) TO NEAREST TREE/SHRUB > 2 M TALL, FROM RANDOM PTS IN SA
BAREVEG :PROP. CT/SA 0-25% COVERED BY EMERGENT/AERIAL (ERECT/FLOATING) VEG; 0-1
DDEVEL : PROP. OF CT/SUBAREA WITHIN .5 KM OF RESIDENTIAL/COMM. STRUCTURE; 0-1
DFL1/2 : PROPORTION OF THE YEAR FLOODED 1 TO 2 M DEEP; 0-1
DFL20/1 : PROPORTION OF YEAR FLOODED 20 CM TO 1 M DEEP; 0-1
DPERMSK : RADIAL DISTANCE TO INCLUDE TOTAL => 30 HA FWPERM, <= 2 M DEEP; KM
FRDRYSK : NUMBER OF YEARS (OR PART OF YEAR) BETWEEN TOTAL DRYDOWNS; 0-15
LOMODVG :PROP. CT/SA 26-50% COVERED BY EMERGENT/AERIAL (ERECT/FLOATING) VEG;0-1

USER-SPECIFIED FUNCTION at level 5, position 1
USUB=(.5*X(1))*X(2)+X(2)
REM WEIGHTED VALUATION FOR TWO DEPTH RANGES

USER-SPECIFIED FUNCTION at level 5, position 3
USUB=X(1)+(X(1)*X(2))
REM WEIGHTED VALUATION OF VEGETATION COVER

```
GRAPH FUNCTION at level 4, position 1
  Title:  PREFERRED HYDROPERIOD/DEPTHS
     X:        0.000,    Y:    0.000
     X:        0.600,    Y:    0.000
     X:        0.900,    Y:    1.000


GRAPH FUNCTION at level 4, position 2
  Title:  FREQUENCY OF DRYING EVENTS, YEARS
     X:        1.200,    Y:    0.000
     X:        2.000,    Y:    1.000
     X:        3.000,    Y:    1.000
     X:        7.000,    Y:    0.100


GRAPH FUNCTION at level 4, position 3
  Title:  MIX OF VEG. COVER: PROP BARE AND LOMOD
     X:        0.000,    Y:    0.000
     X:        0.700,    Y:    1.000
     X:        1.000,    Y:    1.000


GRAPH FUNCTION at level 4, position 4
  Title:  AVG. DISTANCE TO NEAREST TREE >2 M TALL
     X:        1.000,    Y:    0.000
     X:        3.000,    Y:    1.000
     X:        9.000,    Y:    1.000
     X:       15.000,    Y:    0.600
     X:     1000.000,    Y:    0.100


USER-SPECIFIED FUNCTION at level 3, position 2
USUB=(X(1)*X(1)*X(2))^.333
REM WEIGHTED GEM OF COVER AND PERCH/NEST TREES


USER-SPECIFIED FUNCTION at level 2, position 1
USUB=(X(1)*X(1)*X(2))^.3


GRAPH FUNCTION at level 2, position 2
  Title:  DISTANCE TO REFUGE HABITAT
     X:        6.000,    Y:    1.000
     X:      100.000,    Y:    0.100
```

```
GRAPH FUNCTION at level 2, position 3
  Title:  PROP. CAT/SA W/IN .5 KM  DEVELOPMENT
     X:        0.000,    Y:   1.000
     X:        1.000,    Y:   0.100
```

Comments:
Subareas must be established according to hydroperiod, and may also be
established on the basis of vegetation.
.
Cover is measured as 10 or more 1 m sq quadrats, taken along transects
or randomly in CT/SA
.
Lower limit of FRDRY reset from nesting data of Bennetts et al., 1988
.

LIFE REQUISITE: REFUGE
Covertypes:
    FWPERM

```
Lev 5     Lev 4     Lev 3     Lev 2     Lev 1
 DFL1/2---sum------gem------gem------prd-LRSI
 DFL20/1---^         |         |         |
 FRDRYSK--grf-------^         |         |
 BAREVEG--usf------grf-------^         |
 LOMODVG---^                           |
                   DWETLSK--grf-------^
```

Habitat variables:
BAREVEG :PROP. CT/SA 0-25% COVERED BY EMERGENT/AERIAL (ERECT/FLOATING) VEG; 0-1
DFL1/2 : PROPORTION OF THE YEAR FLOODED 1 TO 2 M DEEP; 0-1
DFL20/1 : PROPORTION OF YEAR FLOODED 20 CM TO 1 M DEEP; 0-1
DWETLSK : RADIAL DISTANCE TO NEAREST => 65 HA FWWETL, TYPICALLY .2-1 M DEEP; KM
FRDRYSK : NUMBER OF YEARS (OR PART OF YEAR) BETWEEN TOTAL DRYDOWNS; 0-15
LOMODVG :PROP. CT/SA 26-50% COVERED BY EMERGENT/AERIAL (ERECT/FLOATING) VEG;0-1

```
GRAPH FUNCTION at level 4, position 2
  Title:  FREQUENCY OF DRYDOWNS, YEARS
     X:        4.000,    Y:   0.000
     X:        8.000,    Y:   1.000
```

```
USER-SPECIFIED FUNCTION at level 4, position 3
USUB=X(1)+(X(1)*X(2))
REM WEIGHTED VALUATION FOR COVER
```

```
GRAPH FUNCTION at level 3, position 2
  Title:  MIX OF VEG. COVER: PROP BARE AND LOMOD
     X:        0.000,    Y:   0.000
     X:        0.700,    Y:   1.000
     X:        1.000,    Y:   1.000


GRAPH FUNCTION at level 2, position 2
  Title:  DISTANCE TO BREEDING AREA; KM
     X:        3.000,    Y:   1.000
     X:      100.000,    Y:   0.100
```

Comments:
Perch/nest trees and presence of development not considered significant
for refuge habitat as they would be for breeding habitat.

DISTANCE FUNCTION:
< not used >

HSI TREE DIAGRAM:

```
Lev 3     Lev 2     Lev 1
 BREED----max------usf--HSI
 REFUGE----^
```

USER-SPECIFIED FUNCTION at level 1, position 1
USUB=X(1)/100
REM ADJUST FOR % BACK TO INDEX

Comments:
<none>

FWCA REPORT

APPENDIX C

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-129

HSI MODEL FOR THE AMERICAN ALLIGATOR

Arnold Banner, U.S. Fish and Wildlife Service

The alligator is an amphibious reptile, of great importance to aquatic communities in Florida and elsewhere in its range. It is a predator on invertebrates (crayfish, snails), fishes, other reptiles, waterfowl and wading birds, and mammals. By its excavation of "gator holes", it creates and maintains refugia for fishes in marshes which experience seasonal drying. The alligator is considered a keystone species of the Florida Everglades.

Although alligators are found in a variety of situations (canals, sloughs, lakes, rivers), these areas all provide those features, or life requisites, needed by the species. By focussing on these common attributes, this model attempts to express habitat suitability for any such "cover type" in Florida.

Recently, Newsom, Joanen and Howard (1987) published an HSI model of the alligator for coastal marshes of the northern Gulf of Mexico ("coastal model"). That model dealt with two requisites, breeding cover and nesting cover. The former requisite is met by having 10 to 20% of the open water deeper than 1.2 m, and 20 to 40% of the wetland as open water. The nesting component also uses the latter variable, plus three other hydrologic variables: interspersion of marsh and ponds, percentage of ponds with water > 15 cm deep, and exposure at low tide. In Florida, alligator habitat may range from permanent water bodies (rivers, lakes, canals), to wetlands with widely fluctuating water boundaries (swamps, prairies and sloughs). Since alligators can create their own water bodies within wetlands (Craighead, 1968), it appears that the coastal model may underestimate habitat suitability for such conditions. Therefore, the present model largely accommodates the factors dealt with in the coastal model, but uses variables which may be more sensitive to fluctuating water levels.

The key environmental variables were established after review of the literature. They include the following :

A. Interspersion of open water and marsh/upland. Alligator habitat may consist of permanent open water bodies, with access to the adjoining marsh, swamp, or uplands (Goodwin and Marion, 1979; Hines, Fogarty, and Chappell, 1968; Newsom, Joanen, and Howard, 1987). The edge/banks of water bodies are used for basking and nesting, while the open waters are used for feeding, and escape from intruders or high temperatures. Habitat suitability, therefore, is related to interspersion of marsh/upland and open water (variable V3 of the coastal model). Suitability is related to the amount of edge associated with a water body. The more irregular the shoreline, the

greater the interspersion. The present model uses the ratio of edge between open water and marsh or upland (EDGEOW), to the area of the cover type (AREA). The "ideal" configuration is postulated to be at least as complex as a one ha square, giving a ratio of 400:1 (m to ha). Optimal for the coastal model is the condition of twelve .2 ha ponds in 6 ha, giving a ratio of 315:1.

B. Hydroperiod/stage duration. Alligators are found in wet prairie and other freshwater marshes in Florida (Goodwin and Marion, 1978), where they either can excavate holes in soft sediments, or escape to adjoining deeper water during drought. Marshes should be deep enough, for long enough, to produce large fishes as prey. Also, drying of alligator holes in marshes exposes young animals to predation from adults (Hines, Fogarty and Chappell, 1968), and exaggerates competition (Craighead, 1968). On the other hand, shallow marsh or hammocks are needed for nesting. Alligators will create nest mounds of mud and any available vegetation (Craighead, 1968).

The Florida model uses two variables, DFL550 (duration of flooding 5-50 cm deep) and DFLDEEP (duration of flooding over 50 cm deep). When added, they approximate hydroperiod. When combined as a ratio (DFL550 divided by DFLDEEP + DFL550) they express water stage distribution. Hydroperiod over the longer term is expressed in FRDRYSK (years between complete drying). It is assumed that prolonged flooding favors the vegetation and forage preferred by alligators. An extensive sediment layer (into the dry-season water table) is assumed to slightly compensate for shorter hydroperiods (variable MUD). Hydroperiod and stage distribution are used as substitutes for coastal model variables V1 (percentage of wetland that is open water) and V2 (percentage of open water > 1.2 m deep). Vegetative coverage (see E. below) also is a substitute for V1.

C. Salinity. Alligators occur in fresh and brackish waters. Chabreck (1971) found them in salinities of 3 to 16 ppt. Woodard (1980) noted that adults were more tolerant than hatchlings, which seemed to be restricted to salinities under 5 ppt. The Florida model expresses salinity tolerances under the variable IONIC (the coastal model does not deal with salinity). It is assumed that 5 ppt or less is optimal, and salinities above 25 ppt are unsuitable.

D. Alligator nests are vulnerable to flooding (Goodwin and Marion, 1978; Hines, Fogarty and Chappell, 1968). Kushlan and Jacobsen (1984) studied nest flooding in the Everglades, and found that annual losses of eggs were 6 to 25 % under natural conditions. Alligators build the nest mounds about a month into the rainy season, and so the clutch height is adjusted to late June water levels. Kushlan and Jacobsen found that water management practices overwhelmed this relationship, and caused major egg mortality. Since much of Florida's surface water is under management, it seems appropriate to

include this factor in the model (FLDNEST). The coastal model finds no habitat value where nest flooding is expected. However, such sites still may be used as drought refugia, or by juveniles or adult males. The user is asked whether the site lacks nest habitat, or whether flooding would cause over 30% mortality of eggs. Either circumstance yields a suitability of .5 for this condition.

E. Vegetation. The alligator uses emergent vegetation as cover and for nest material. They use a wide variety of species (Goodwin and Marion, 1978). Artificial lakes or canals may be too steep-sided to offer vegetated littoral zones. The extent of wetland vegetation is derived by summing three variables representing the proportions of the wetland having different vegetative densities (LOMODVG, HIMODVG, DENSVEG). The remainder of the wetland would have sparse vegetation (< 26% coverage), presumably satisfying the coastal model's open water requirement (V1).

F. Disturbance. While alligators are relatively tolerant of human intrusions, humans often are intolerant of the presence of large alligators. Because of this incompatibility, the model uses the proportion of the wetland within .5 km of residential or commercial development as an indicator of suitability (DDEVEL).

Operation of the Model

An HSI model represents mathematically the sensitivity of a species to key environmental variables. In any given situation, the model should identify which habitat factor would be "limiting" and, based on this, calculate the habitat's suitability (or carrying capacity). Suitability is expressed as an index, 0 being the least suitable habitat, and 1.0 being the ideal.

The model typically is represented by a tree diagram, read from left (input environmental variables) to right (Habitat Suitability Index, HSI). The index is developed in two steps: first, each variable (or group of variables) is rated individually, according to the species requirements and tolerances, and given an intermediate suitability index value (again, 0 to 1.0). Second, these index values are combined in a manner reflective of their real-world importance, or effect. The means of combination include addition (sum), calculating the geometric (gem) or the arithmetic (mea) means, multiplication (prod), minimum (min) or maximum (max), graph function (grf), or user specified formula (usf).

The input variables are expressed immediately below the tree diagram; below them are the formulas and graphic relations used in the tree diagram. This model is intended for use in habitat evaluation anywhere in Florida. The model deals with alligator habitat as a single cover type.

Literature Cited

Chabreck, R.H. 1971. The foods and feeding habits of alligators from fresh and saline environments in Louisiana. Proc. Southeastern Assoc. Game and Fish Comm. 25:117-124.

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----------. 1979. Seasonal activity ranges and habitat preferences of adult alligators in a north-central Florida lake. J. Herpetology 13(2):157-164.

Hines, F.C., M.J. Fogarty and L.C. Chappell. 1968. Alligator research in Florida. Proc. Southeastern Assoc. Game and Fish Comm. 22:166-180.

Kushlan, J.A. and T. Jacobsen. 1984. Management of alligator nest flooding. South Florida Research Center, Nat. Park Service,. Homestead, Fla.

Newsom, J.D., T. Joanen and R.J. Howard. 1987. Habitat Suitability Index Models: American Alligator. Biol. Rept. 82(10.136). U.S. Fish and Wildlife Serv., Wash., D.C.

Woodard, D.W. 1980. The American Alligator. FWS/OBS-80/01.39, U.S. Fish and Wildlife Service, Wash., D.C.

Library: C:LATEST.HLB
2-8-1990

Model # 11 Single covertype model.
Model name: AMERICAN ALLIGATOR 1.2a
Verification level: Author Draft
Creation/modification date: 12-21-1988

Covertypes:
FWWETL : FRESHWATER (<5 PPT), TYPICAL DRYING INTERVAL .1 TO 6 YEARS
FWPERM :FRESHWATER (<5 PPT) ZONE OR DISCRETE, TYPICAL DRYING INTERVAL => 6 YRS
SWWETL : SALINE (=>5 PPT) ZONE OR BODY, FLOODED AND EXPOSED ON > 30 DAYS/YEAR
SWPERM : SALINE (=>5 PPT) ZONE OR BODY EXPOSED ON < 30 DAYS PER YEAR

```
Lev 7    Lev 6    Lev 5    Lev 4    Lev 3    Lev 2    Lev 1
         DFL550---usf------grf------gem------usf------prd--HSI
         DFLDEEP---¦                 ¦        ¦        ¦
MUD------grf-------^                 ¦        ¦        ¦
                  FRDRYSK--grf-------¦        ¦        ¦
DFL550---usf------grf------gem-------^        ¦        ¦
DFLDEEP---^                 ¦                 ¦        ¦
         DDEVEL---grf-------^                 ¦        ¦
         HIMODVG--sum------grf------mea-------^        ¦
         DENSVEG---¦                 ¦                 ¦
         LOMODVG---^                 ¦                 ¦
         EDGEOW---usf------grf-------^                 ¦
         AREA------^                                   ¦
                                     FLDNEST--min------^
                            IONIC----grf-------^
```

Habitat variables:
AREA : SURFACE AREA OF COVER TYPE OR SUBAREA; HA
DDEVEL : PROP. OF CT/SUBAREA WITHIN .5 KM OF RESIDENTIAL/COMM. STRUCTURE; 0-1
DENSVEG : PROP. CT/SA >75% COVERED BY AERIAL/EMERGENT (ERECT/FLOATING) VEG; 0-1
DFL550 : PROPORTION OF TIME CONTINUOUSLY FLOODED 5-50 CM DEEP, ANNUALLY; 0-1
DFLDEEP : TOTAL PROPORTION OF YEAR FLOODED > 50 CM; 0-1
EDGEOW :TOTAL EDGE OF OPEN WATER (<.25 VEG. COVER); MEASURE FEATURES=> .1HA; M
FLDNEST : ALLIGATORS NEST HERE, AND <.3 ARE FLOODED ANNUALLY = 1.0; ELSE = .5
FRDRYSK : NUMBER OF YEARS (OR PART OF YEAR) BETWEEN TOTAL DRYDOWNS; 0-15
HIMODVG :PROP. CT/SA 51-75% COVERED BY AERIAL/EMERGENT (ERECT/FLOATING) VEG;0-1
IONIC : PREVALENT SALINITY WHEN SURFACE WATERS PRESENT; PPT
LOMODVG :PROP. CT/SA 26-50% COVERED BY EMERGENT/AERIAL (ERECT/FLOATING) VEG;0-1
MUD : PROP. OF CT OR SUB.A W/> 1' SED. DEPTH (INTO DRY SEASON W.TABLE); 0-1

GRAPH FUNCTION at level 6, position 3
Title: PROPORTION OF CT/SA W/ SED > 30 CM
X: 0.000, Y: 0.000
X: 1.000, Y: 0.100

```
USER-SPECIFIED FUNCTION at level 6, position 4
IF X(1)+X(2)=0 THEN USUB = 0: RETURN
USUB=X(1)/(X(1)+X(2))
REM WEIGHTS TIME IN EACH DEPTH CATEGORY


USER-SPECIFIED FUNCTION at level 5, position 1
USUB=X(1)+X(2)+X(3)
IF USUB> 1.0 THEN USUB = 1.0


GRAPH FUNCTION at level 5, position 3
  Title:  DISTRIBUTION OF WATER DEPTHS, TIME
     X:        0.000,    Y:   0.500
     X:        0.300,    Y:   1.000
     X:        0.800,    Y:   1.000
     X:        1.000,    Y:   0.330


GRAPH FUNCTION at level 5, position 4
  Title:  PROPORTION OF CT/SA W/IN .5 KM OF DEV.
     X:        0.000,    Y:   1.000
     X:        1.000,    Y:   0.100


USER-SPECIFIED FUNCTION at level 5, position 6
USUB=X(1)/X(2)
REM EDGE AREA INDEX


GRAPH FUNCTION at level 4, position 1
  Title:  TOTAL DURATION OF FLOODING
     X:        0.000,    Y:   0.000
     X:        0.500,    Y:   0.250
     X:        0.750,    Y:   0.500
     X:        1.000,    Y:   1.000


GRAPH FUNCTION at level 4, position 2
  Title:  MEAN YEARS BETWEEN DRYING EVENTS
     X:        0.000,    Y:   0.000
     X:        2.000,    Y:   0.500
     X:        6.000,    Y:   1.000


GRAPH FUNCTION at level 4, position 4
  Title:  TOTAL PROPORTION W/VEG > .25
```

```
    X:        0.000,   Y:   0.000
    X:        0.250,   Y:   1.000
    X:        0.800,   Y:   1.000
    X:        1.000,   Y:   0.200
```

GRAPH FUNCTION at level 4, position 5
Title: EDGE TO AREA RATIO

```
    X:        0.000,   Y:   0.000
    X:      400.000,   Y:   1.000
    X:     1000.000,   Y:   1.000
```

GRAPH FUNCTION at level 3, position 4
Title: SALINITY TOLERANCE

```
    X:        0.000,   Y:   1.000
    X:        5.000,   Y:   1.000
    X:       25.000,   Y:   0.000
```

USER-SPECIFIED FUNCTION at level 2, position 1
USUB=(X(1)*X(1)*X(2))^.3

Comments:
HYDROLOGY VARIABLES MODIFIED TO ACCORD WITH M. FLEMING'S EVERGLADES DATA
WEIGHTED GEOMETRIC MEAN TO GIVE GREATER WEIGHT TO HYDROLOGY
CHANGES TO HYDROLOGY GRAPHS IN RESPONSE TO COMMENTS REGARDING
INTERPRETATION OF POND/USE DATA, BY G. DALRYMPLE

FWCA REPORT

APPENDIX D

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

Miccosukee Tribe of Indians of Florida

P.O. BOX 440021, TAMIAMI STA., MIAMI, FLORIDA 33144
TELEPHONE: 305 / 223-8380

Appendix D:
Response from Miccosukee Indian Tribe

COUNCIL
BUSINESS & GENERAL

BILLY CYPRESS
CHAIRMAN

JASPER NELSON
ASS'T. CHAIRMAN

JIMMIE BERT
SECRETARY

BETTY H. OSCEOLA
TREASURER

HENRY BERT
LAWMAKER

June 30, 1989

Mr. David Ferrell, Field Supervisor
U.S. Dept. of Interior
Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

Dear Mr. Ferrell:

The U.S. Fish and Wildlife Service and the Miccosukee Tribe of Indians of Florida are both concerned about the impacts of lowering the water levels in WCA-3A south to provide water to Northeast Shark River Slough, albeit for different reasons. The Tribe's staff and consultant have concluded that the upstream stage at the S-12B Gate Structure in the L-29 borrow canal has to be at or above 7.4 feet N.G.V.D. in order for our airboat concession to operate safely and to allow tribal members to carry on their traditional way of life in the hammocks of WCA-3A.

The Tribe's staff has met with Mr. Rolando Altamirano of the Corps of Engineers and his staff on two separate occasions. At these meetings, the Tribe proposed three alternatives to mitigate tribal concerns on water levels in the impacted area. These were to maintain a stage of 8 feet N.G.V.D., to deepen the airboat trails by demucking to caprock, or to provide specialized equipment such as full tracks. The Corps is pursuing the second alternative, deepening the airboat trails. The Tribe prefers to retain the stage at 7.4 feet at the upstream gage at the S-12B Gate Structure.

The Tribe shall inform the Corps of our preference. We have lowered the amount of water necessary to operate our airboats based on when the airboat concession stopped operating this year due to the drought we are currently experiencing.

CONSTITUTION APPROVED BY SECRETARY OF THE INTERIOR, JANUARY 11, 1962

The Tribe appreciates your support of our position of maintaining the water levels at certain stages. If you require further information, please contact Mr. Steve Terry, Land Resources manager for the Tribe at the above address and/or telephone number.

Sincerely,

Billy Cypress
Tribal Chairman

CC: Jasper Nelson, Assistant Chairman
Newton Lamar, Government Programs Manager
Steve Terry, Land Resources Manager
Gene Duncan, Water Resources Manager
Gail Milleson, Tribal Consultant

FWCA REPORT

APPENDIX E

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

M E M O R A N D U

TO: P.B. Rhoads, Director, Resource Planning Department
Fred Davis, Deputy Director, Resource Planning Department

FROM: J. Walter Dineen, Director, Environmental Sciences Division. JWD

DATE: November 18, 1985

SUBJECT: Agricultural Flow-Way Concept

With the continuation of the water quality problems of Lake Okeechobee backpumping, and even the long term quality problems of pumping into the WCA's, it becomes imperative that the District attempt to find a solution to the ever-degrading water quality of the Everglades Agricultural Area.

I would like to present a concept of a flow-way for handling the water presently pumped by S-3 into Lake Okeechobee and S-8 into WCA3A. This concept is not new, but I doubt if anyone in the past has examined the pros and cons of such an idea. Consider this memo as an initiator of discussion.

For discussion purposes, I recommend acquiring a one-mile wide swath along the Miami Canal through the agricultural area. For simplicity purposes, I have indicated a half-mile wide area taken from each side of the Miami Canal. The actual direction of the swath is negotiable depending upon such things as present property and canal alignments, but the mile width should remain as the standard.

The Miami Canal between S-8 and S-3 is approximately 26 miles long. If the northern most mile is deleted from consideration a flow-way 25 miles long can be developed south to S-8 pump station. This flow-way (25 miles x 1 mile) encompasses 16,000 acres. The flow-way should be capable of containing surges up to four feet in depth. This allows for a maximum storage capability of 64,000 acre feet of water. Of course, care should be taken to avoid four foot depths, and this should only occur during or after storm conditions. During some months of the year, 32,000 acre feet of water could be stored in the flow-way for recycling to the Ag area. That is, Ag could irrigate from the flow-way and pump back into it as necessary. During dry periods, all of the flow-way storage would be used first in irrigation demands.

During rainy periods, when agriculture is more in a pumping mode rather than an irrigation mode, water stored in the flow-way in excess of the 32,000 acre feet could be moved north into the Lake or south into WCA3 as required and as water quality dictates. Some times, water could be gravity flowed from the flow-way to the Lake or WCA, depending upon the stage in each. Water can also easily be gravity flowed through the Holey Land into eastern WCA3, and perhaps through the Rotenberger into the western side of WCA3A (The Rotenberger plans should compliment the flow-way plan). This gravity flow may eliminate much pumping cost at S-8, the Holey Land/Rotenberger and even some at S-3.

The flow-way must be contained by levees on each side. The existing levees and spoil adjacent to the Miami Canal would be moved to the outside limits of the flow-way if economically feasible. The Miami Canal itself will be

left intact as a conveyance canal for dry period water transport. The flow-way dikes will undoubtedly require more fill than offered by that presently existing along the Miami Canal. Borrow fill for the new levees should be taken from immediately outside of the diked flow-way, the adjacent borrow canal to be used as a seepage control canal. The flow-way will leak at high stages. Seepage water can be collected in the outside borrow canal and returned to the flow-way by pump stations.

The flow-way will have to be vegetated. This will be a several year process. The hydroperiod in the flow-way will be extremely variable, and some aquatic plants may have difficulty becoming established. The flow-way would most likely require water management at the beginning of each rainy season so as to establish each year's annual vegetation, and strengthen the perennial vegetation for maximum productivity and nutrient uptake. An investigation of waterfowl plantings would be imperative. Perhaps the GFC could plant known waterfowl food plots in portions of the flow-way. Fish and wildlife would surely be benefitted in most years, but it must be clearly understood by all agencies that fish and wildlife benefits are secondary spin-offs. The flow-way would be managed for nutrient removal primarily, so that primary fish and wildlife benefits accrue to the WCA's, ENP, and Lake Okeechobee.

Although the flow-way does not extend completely to the Lake, the northernmost mile of Miami Canal will have to be diked on either side with a levee capable of containing a stage of 17 1/2 ft msl. This will allow for discharge from Lake Okeechobee when the Lake exceeds its regulation schedule. The flow-way will carry much of the water normally assigned to discharge thru S-80 into the St. Lucie Estuary, and thru S-79 into the Caloosahatchee Estuary. Thus, the flow-way also becomes the much talked about "third outlet from the Lake."

MIAMI CANAL AG FLOW WAY

NEED TO KNOW SECTION

1. Construction details and design of levee to hold four feet of water (should be already known from Holey Land studies).

2. Number of relocations: pump stations, bridges, whatever.

3. Evapo-transpiration loss from 16,000 acres of new flow-way.

4. Average annual volume that could be recycled to Ag lands adjacent to flow-way.

5. Average annual volume passed into WCA-3 after being discharged from Lake for use by farmers.

6. Soil sampling in flow-way. Nutrient levels, pesticide levels, any toxic substances.

7. Land elevation from north to south along proposed flow-way. Will water in flow-way lean one way? Are small cross berms necessary in flow-way?

8. (a) Impact on Lake water budget.
   (b) Impact on WCA3A water budget
   (c) Impact on ENP flows and volumes.

BENEFITS OF PROJECT

1. Water quality enhancement. Reduces nutrients in pumped water prior to going to Lake or WCA3A. (Via flow-way/marsh uptake).

2. Allows some water storage in 16,000 acres for recycle delivery to Ag people. Stops constant use of L.O. water for irrigation except in rainfall deficient periods. Less draw on Lake Okeechobee. More actual recycling of Ag water.

3. Water quantity enhancement. Reduction of nutrients in flow-way allows backpumping of decent quality water into Lake Okeechobee - thus affects water storage enhancement in Lake.

4. Flow-way design allows for "third outlet" from Lake Okeechobee to Water Conservation Area, thus relieving pressure of Zone A discharges to St. Lucie (and Caloosahatchee) so disruptive of estuary ecology.

5. Saves District pumping cost at Lake or WCA3A. At times water can be gravity flowed from flow-way because of higher stages.

6. Should be eligible for federal monies for construction.

SUMMARY

1. Take a one-mile wide swath along the Miami Canal through the Ag area. For simplicity purposes I have shown a half-mile taken from either side of the Miami Canal.

2. Construct levees (move existing Miami Canal levees as much as practicable and possible) on outside of this one mile wide flow-way. If more dike fill is required, dig borrow from outside of flow-way dikes to use as seepage control and return seepage ditch. If cheaper to build new dikes, old Miami Canal levees must be seriously breached.

   One mile wide x 25 miles = 16,000 acres. Flow-way should be capable of surges up to four feet depth (64,000 acre feet of water).

   A. Flow-way will be planted with aquatic vegetation.

   B. Flow-way will take 32,000 acre feet storage before any attempt is made to move water north or south (<u>What stage in flow-way will that be?</u>).

   C. Water can be moved south to WCA3A or north to Lake depending upon H_2O quality.

   D. Many times, water can be gravity flowed into Lake or WCA3A (eliminates pumping costs).

3. Flow-way can be used as third outlet from Lake to decrease estuarine discharges.

June 19, 1986

PRELIMINARY CONCEPT FOR AN EVERGLADES AGRICULTURAL AREA FLOW-WAY

To solve the backpumping issue itself, large regional reservoirs would probably be more cost effective. It has been pointed out clearly that my 25 mile^2 flow-way concept requires 50 miles of large dikes. A 25 mile^2 regional reservoir in a square shape requires only 20 miles of large dikes (5 miles on a side). The regional reservoir would require a network of interior canals on approximately one-mile centers. This would be necessary to get the water out of the area for irrigation purposes. My long flow-way concept has this built in already.

My concept of an Everglades Ag Area (EAA) flow-way was put together in November, 1985 prior to the Lake Okeechobee Technical Committees. I felt that we had gone on too long looking piece-meal at each and every problem as they individually erupt concerning the Lake Okeechobee/Everglades eco-system. If the narrow goal sought is merely to discontinue backpumping to the Lake from the EAA, then my vision of a flow-way is overkill. However, even if we solve this individual particular problem and eliminate the backpumping, we shall still be operating the Water Management District in the normal mode of handling one problem at a time, continuing our shallow overview of immediate problems without breaking out of the mold to look at the big picture. Somewhere, sometime, we really should look at ecosystem management. I would appreciate it if the reader would expand his mind and try to follow along with ecosystem repercussions and management.

(a) The major assumption, of course, is that the flow-way will be useful in absorbing nutrients and be beneficial in cleansing the water. Behind this assumption is the belief that we can establish vegetation in the flow-way to aid in nutrient removal. This can take two forms; (a) a marsh, with both perennial and annual plants and (b) some carefully managed hyacinth patches. There are ample data available in the literature concerning the nutrient removal capabilities of aquatic vegetation (see Appendix 1).

(b) The technical and engineering feasibility is a given. We now need State level cooperation to undertake a project of this magnitude, and a strong cooperative spirit from the private sector to end a long continuing series of environmental problems once and for all.

(c) The cost of agricultural land in the Miami Canal Basin is about $3000/acre which includes crop and stubble severances if necessary. Cattle land would be somewhat less, although much of the land in a proposed flow-way appears to be in cane. Although there are 25 miles^2 in the flow-way, about eight square miles lies in the Holey Land/Rotenberger areas. Thus, the requirement for purchase or trade is reduced to about 17 miles^2. Also, there are about 21,000 acres of State owned land in the EAA (about 1,000 acres adjacent to the Miami Canal) which can be traded for flow-way right of way. This 20,000 remaining State owned acres far exceeds the 10,000 remaining required acres for the flow-way if trades can be realized. There need not be any direct land costs with cooperative private and State sectors. Otherwise, if the land is to be purchased, we are looking in the neighborhood of $29,000,000.

Dikes to contain the flow-way may cost about $300,000/mile x 50 miles = $15,000,000 (more if the Corps does the design). These dikes are necessary to control the water in the flow-way and prevent any flooding of the Ag lands adjacent to the flow-way.

There are approximately 25 relocations of existing pumping stations and culverts. These stations would have to be moved back to the outside edge of the floodplain of the flow-way. In some cases pump stations are already sufficiently removed from the Miami Canal so as to be outside the flow-way, and only the project and private culverts entering the Miami Canal need be relocated. There are inumerable other intrusions upon the right-of-way (railroads, highways, powerline crossings, monitoring wells, gages, etc.) that have to be dealt with. No costs have been derived for this yet.

Ordinary rainfall events during the June thru October rainy season generate about 4,000 acre feet/day for two or three day periods. Our present mode of operation currently sends all of this water southward. The flow-way itself has the capacity to store 64,000 acre feet, albeit this would induce depths of four feet in the flow-way, and would only be allowed for emergency purposes. The operating range of storage in the flow-way would probably be up to 48,000 acre feet (3 feet deep). Large rainfall events can generate up to 90,000 acre feet of water over a seven day period, but these are relatively infrequent occurrences. The flow-way would be busy moving water south and north under these conditions. S-8 would certainly be pumping, and perhaps S-3 would have to be used, although computer routings do not indicate this. Ordinary rainfall events which occur while the flow-way is two to three feet deep can be gravity released through S-8 into WCA3A, and also

released into the northeast portion of WCA3A, via the Holey Land project. Water of acceptable quality can be returned to the Lake for future storage.

There are approximately 34,000 acres in the Holey Land now that the "toe of the boot" is being incorporated into the present project. Excess water from the flow-way can be continually flowed through the Holey Land into WCA3A during normal rainfall events. Present plans call for a 750 cfs pump station at the northwest corner of the Holey Land to pump from the Miami Canal into the Holey Land. The outlet capacity (fourteen 72 inch culverts) far exceeds the present input capacity (with a .5 foot head across L-5). The S-8 pump station and Holey Land pump station are both high and dry at a flow-way stage of 16 ft msl. Both will be sufficiently high to avoid flooding.

It appears from the preliminary computer routing that: (1) The flow-way provides more water to the EAA than does the present mode of operation (IAP); (2) Less water is put into WCA3A from the Miami Canal Basin than presently under the IAP; (3) The flow-way, Holey Land, and WCA3A were able to handle all of the runoff generated in the Miami Canal Basin. That is, no water was backpumped into Lake Okeechobee through the entire period analyzed (1963 to 1982); (4) Some quantity of water was required from Lake Okechobee to meet demands for the EAA not met by the flow-way storage. This occurred generally during dry years (spring months); (5) Lake Okeechobee peak stages are reduced; (6) Regulatory discharges to the estuaries are reduced.

The value of the flow-way is enhanced by being available for discharges from Lake Okeechobee in lieu of large discharges to the St. Lucie Estuary. While it could not take maximum St. Lucie discharges (12,000 cfs), it could be used

for early Lake control with discharges of 2,000 cfs or so. Sustained releases of this sort, passing through the Holey Land and WCA3A, would be eventually passed into WCA3B (to a stage of 9.0) by modifications in the L-67A dike which separates WCA3A from WCA3B. Ultimately, L-29 at the southern end of WCA3B would be modified to allow flows into the Northeast Shark Slough (we now use S-333 and the old Tamiami Trail borrow canal for this). When all of the separate pieces are reglued together, we finally have eco-system management. This concept of a flow-way opens all sorts of management options.

FWCA REPORT

APPENDIX F

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-149

United States Department of the Interior

FISH AND WILDLIFE SERVICE

P.O. BOX 2676

VERO BEACH, FLORIDA 32961-2676

November 9, 1989

TO ADDRESSES ON ATTACHED LIST

Dear Sirs:

Because of your recognized expertise and/or interest in the Federal project to modify water deliveries to Everglades National Park, I am requesting your input on the four alternative plans under consideration. I will use this information in developing the Fish and Wildlife Service's Coordination Act Report and our Biological Opinion regarding effects on threatened and endangered species.

The enclosed information was largely derived from model runs for the alternatives. It displays hydrological conditions that would have occurred during the period 1969 through 1982, had the project and other structural and operational features been in place, and water demand been that anticipated for the year 1990. The data reflect conditions over a number of wet and dry years. Effects from errors in predicting supply or demand are largely mitigated by making comparisons between model runs, which experience the same conditions.

I have tabulated and graphed a number of measures of effect, limiting my interpretations at this stage. The Service's findings and recommendations, of course, will be based on interpretations of these data. I would greatly appreciate any views you may care to provide, within the next 30 days.

Sincerely,

Arnold Banner

Arnold Banner, Ph.D.
Senior Field Biologist

Enclosures

Appendix F:
Data Inquiry Package

ADDRESSEES

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Dr. Manley Fuller
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ALTERNATIVES

Base is the no action alternative (model run BA90). This would return water flows to the minimum delivery schedule set by Congress in 1970. This plan would require no structural modifications, or flood protection for the East Everglades.

Basic Raindriven (model run MU90) delivers water according to rainfall conditions. It has structural modifications to direct flows through Water Conservation Area 3B and to protect developed areas from the resulting higher stages. Features include: three gated plugs in canal L-67, and three structures and sets of levees leading through L-67 into 3B; two structures leading from 3B into Northeast Shark Slough; removal of the L-67 extension; seepage pumps and levees to reduce or control flows eastward into developed areas.

Modified Minimum (model run BC90) and the following are alternatives developed by the Fish and Wildlife Service. This delivers water according to the minimum delivery schedule (including the guaranteed deliveries), and includes only those structural features of the raindriven plan found south of Tamiami trail. The removal of L-67 redirects a portion of flows into Northeast Shark Slough.

Modified Rain Driven (model run MP90) includes the same structures as used in alternative 2, except that the gated plugs are not used. In this plan, when stages in Water Conservation Area 3A fall below 9', additional water is brought south from Lake Okeechobee. In all other plans, this occurs when 3A stages fall below 8.5'. Additionally, when the internal canals fall below 7.5', all water users face 15% cuts in allocations. These features were designed to retain some of the long hydroperiod conditions found under the base.

EXPLANATION OF ATTACHMENTS

Enclosed are the following:

Table Summary information developed to shed light on impacts or benefits; this includes:

Drought refugia, particularly for snail kites This displays the number of cells in kite habitat which retain water over most or all drought events, over the 14 year period of record.

Drought interval at gauge 3-28 This is the number of years in which water went below ground at this gauge in WCA3A (see map for location), a measure used in the kite extinction model being developed by S. Beissinger.

Number of cells remaining flooded in Areas 3A and 3B, by year This is another measure of the frequency and intensity of drying in Water Conservation Areas 3A and 3B.

Frequency of drying at S12B This determines the impact of water level reductions in WCA3A on the Miccosukkee Indians' use of airboats.

Cumulative flooding This tabulates average percent of flooding to 5 cm deep or more. The values reflect the amount of water held over the study area. The reader is cautioned that short term flooding of a large area can give the same average percent as longer flooding of a small area.

Habitat suitability from the wood stork model This examines the drying conditions each winter/spring of the period of record and computes suitability for production of fledglings. This model was developed using records for the period 1969 through 1986.

Impact of construction This suggests the complexity of the proposed work and the extent of wetland to be eliminated.

Effect on Lake Okeechobee Two alternatives change Okeechobee stages a small degree.

Topographic map This shows ground elevations in the project area, derived from Corps of Engineers data and information provided by Everglades National Park. These elevations, in combination with water stage data from model runs, were used to develop the attached hydroperiod information.

Hydroperiod Four figures show the hydroperiod value of each 4 square mile grid cell in the project area for each alternative. The values are expressed as average duration of flooding events over the 14 years.

Percentage of time flooded Four figures show the percent of the 14 year period of record that each cell has 5 or more cm of water.

Wood stork model output This graph contrasts habitat suitabilities of the four alternatives, based on their 14 year records.

Drought refugia This graph compares the extent of habitat remaining flooded for 6 to 14 years for each alternative.

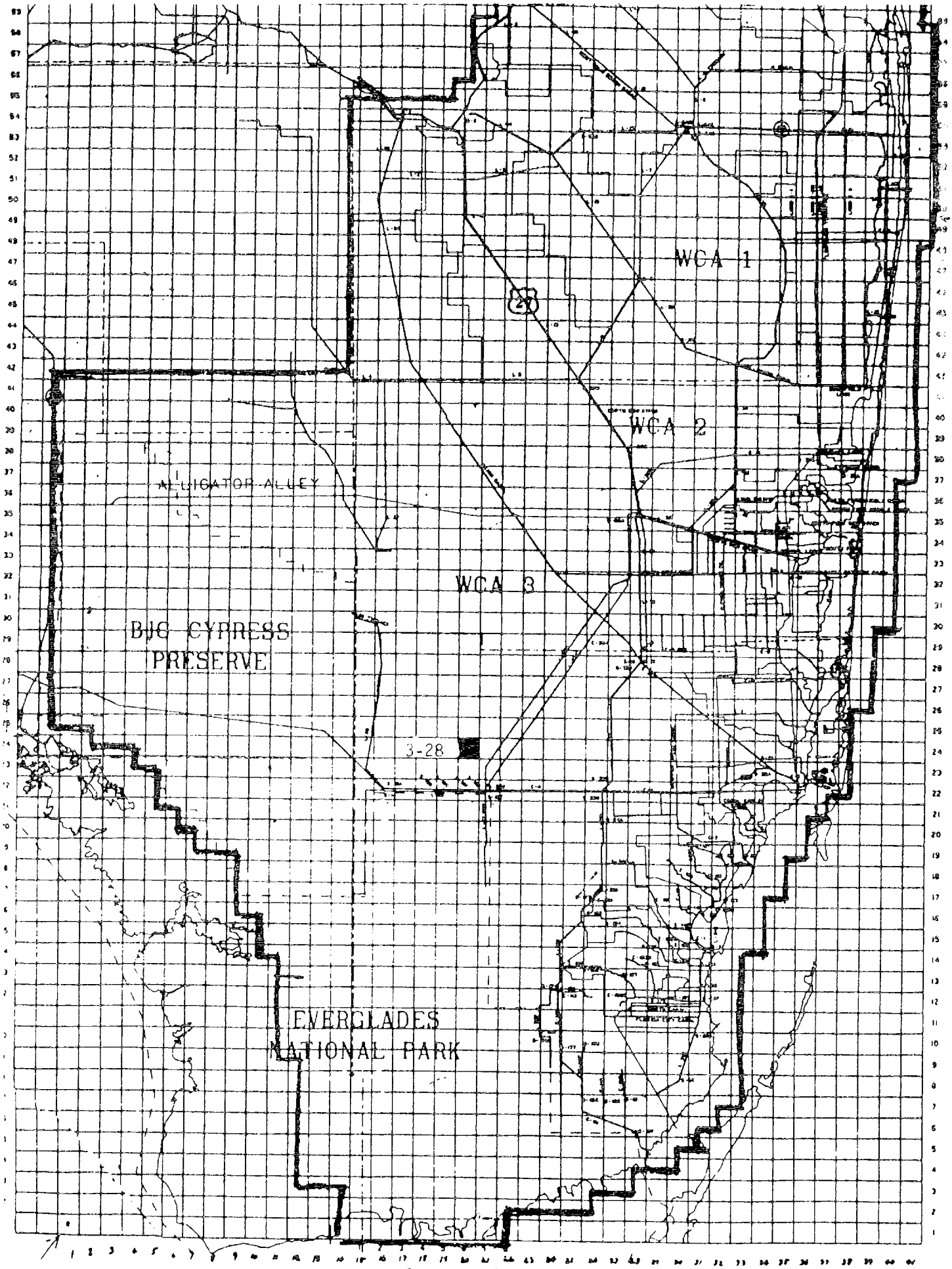
Degree of change due to the project Three figures contrast the percentage of time flooded, under the base and the other alternatives.

Effect on Okeechobee Seven graphs show the stages in Lake Okeechobee associated with each alternative.

Summary of Attributes of Water Delivery Alternatives

ATTRIBUTES	ALTERNATIVES			
	BASE (BA90)	MODIFIED MINIMUM (BC90)	MODIFIED RAINDRIVEN (MP90)	BASIC RAINDRIVEN (MU90)
Drought refugia (sq. miles):				
area flooded 6<>14 yrs:	32	20	28	0
area flooded all 14 yrs:	16	28	0	0
Occurrence of drying at Gauge 3-28:				
number of years in which water went below ground at 3-28:	1	2	4	6
Number of cells flooded entire year:				
1969	150	149	147	152
1970	165	167	166	166
1971	18	20	29	8
1972	128	130	132	134
1973	3	7	0	0
1974	11	12	9	0
1975	30	32	46	18
1976	43	49	69	53
1977	45	47	59	46
1978	85	90	105	103
1979	112	114	119	114
1980	122	125	132	121
1981	20	22	29	3
1982	47	53	45	75
Effects on WCA3A Indian airboat use:				
(requires stage => 7.4' at S12B) number of months too dry, over 14 year period of record:	16	11	14	18

	BASE (BA90)	MODIFIED MINIMUM (BC90)	MODIFIED RAINDRIVEN (MP90)	BASIC RAINDRIVEN (MU90)
Average flooding:				
average percent of time cells flooded > 4 cm deep:				
WCA3A (111 cells)	83	84	86	84
WCA3B (36 cells)	69	71	72	70
NESS (55 cells)	38	45	51	49
ENP (175 cells)	49	48	47	46
Results from wood stork habitat model (based on proportion of range drying over 4 months):				
percentage of base:	100	116	78	89
Impacts of operation and construction:				
Complexity: new operable structures needed;	0	2 seepage pumps, levees	2 seepage pumps, levees 8 gated structures and levees	2 seepage pumps, levees 8 gated structures and levees
Wetland impacts	0 0	fill 98 acres 1600 acres drained	fill 165 acres 1600 acres drained	fill 165 acres 1600 acres drained
Water requirements	existing	existing	supplementary	existing
Lake Okeechobee stages (for 14 years):				
number of months stage more than .1' lower than base:		0	51	0
number of months stage more than .1' above base:		0	11	104


WCA 1
WCA 2
WCA 3
ALLIGATOR ALLEY
BIG CYPRESS
PRESERVE
3-28
EVERGLADES
NATIONAL PARK

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NORTH →

ELEVATIONS IN FEET, NGVD

8/16/89 : BNP AND COE DATA

Y / X COORD.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
10												1	1	1	3	4	5	6.6	6.4	7	8	8.5	9.2	10	10.	12.	13.	13.	13.
11										1.1	0.9	1.8	2.4	1.5	2.5	4	5	6.8	7	7.5	8.4	8.5	9.2	10.	11.	12.	12.	12.	12.
12									1	3	1.5	2.1	2.7	2	3.5	4	5.7	6.8	7.3	7.7	8.5	8.8	9.3	10.	11.	12.	11.	11.	11.
13									1.2	3.9	2.4	2.5	3.3	4.0	5	5	6	6.8	7.5	8	8.5	8.8	9.2	10.	11	11	11.	11.	11.
14	0.7	1	1.2	1.7	0.5	0.6	3	3.1	2.5	4	3.4	3.3	3.7	4.7	5.3	6.3	6.7	7.2	7.8	7.5	8.5	8.8	9.4	10	10.	11	11	11	11
15	0.9	1	1	0.8	0.7	0.8	0.9	1.5	2.1	2.9	3.9	4.4	4.9	5.6	6.4	6.9	7.5	8	8.2	8.3	8.5	8.5	9	9.5	10.	10.	10.	10.	10.
16	1	1.3	1.5	1.3	1.2	1.2	1.4	1.7	2.5	3.2	4.1	4.5	5.2	6.1	6.7	7.1	7.5	7.9	8	8	8.1	8.2	8.5	9	10	9.5	9.7	9.8	10
17	1	1.6	2.8	2.8	2	2.2	2.2	2.4	3	3.5	4.2	4.9	5.5	6.0	6.4	7.1	7.5	7.8	7.9	7.7	7.8	7.9	8.4	8.7	9.3	9.2	9.7	9.7	9.9
18	2.5	3.2	3.7	3.5	3.3	3.5	3.4	3.4	3.5	3.9	4.4	4.7	5.3	5.7	6.3	6.6	7.5	7.6	7.7	7.8	7.8	8	8.3	8.4	8.7	8.9	9.6	9.6	10.
19	2.8	3.8	4.2	4.5	4.5	4.8	4.8	4.6	4.6	4.4	4.7	5.1	5.3	5.6	6.1	6.6	7	7.3	7.4	7.6	7.8	8.2	8.1	8.3	8.6	8.8	9.3	9.5	10
20	1.2	3.2	4	5.2	5.9	5.3	5.4	5.5	5.4	5.5	5.5	4.8	5.5	5.6	5.8	6.4	6.6	7.1	7.3	7.5	7.6	7.9	8.1	8.3	8.5	8.8	9.1	9.2	9.5
21	1.6	2	4.5	5.7	6.7	5.5	5.8	5.8	6.5	6.1	6.2	5.6	5.6	5.7	5.9	6.1	6	6.5	7.1	7.2	7.5	7.8	8	8.2	8.5	8.8	9	9	9
22	1.3	1	3.7	4.5	6.7	5.0	5.1	5.9	6.8	6.2	6.6	6.3	5.9	5.4	5.6	5.9	6.2	6.5	7	7.1	7	7.4	7.6	8.1	8.2	8.4	8.6	8.6	8.5
23	1.8	2.1	1.2	4	5.4	5.1	5.5	5.7	6.2	6.4	7.4	6.4	6	5.8	5.6	5.8	6	6.2	6.5	6.9	7	7.1	7	7.9	7.8	8	8	8	8
24	1.8	2	2	3.4	5.4	5.6	6.9	6.6	7.4	6.8	7.1	6.7	6.5	6.2	5.5	5.8	6	6.5	6.4	6.5	6.9	6.7	6.8	7.2	7.5	7.5	7.2	7.6	7.7
25			4'	5'	6'				7.5	7.2	7.8	7.7	6.9	6.3	5.7	5.9	7	6.6	6.3	6.2	6.5	6.8	6.9	6.8	7.1	7	7	7.4	7.6
26									8.8	8.5	8.3	8.3	7.5	7.3	7	7	7	6.5	6.4	6.2	6.4	6.6	6.6	6.9	7	6.9	6.8	7.3	7.5
27									9.2	9.3	9.4	8.8	7.7	7.3	7	6.3	6.5	6.6	6.8	6.9	5.8	6.1	6.1	6.4	6.5	6.8	6.8	7.2	7.5
28									9.6	10	10	9.6	8.1	8	7.5	6.8	6.1	7	6.8	6.4	5.5	5	5	5.3	5.5	5.7	6.2	6.5	7.3

4' 5' 6' 7'

6' 6' 7'

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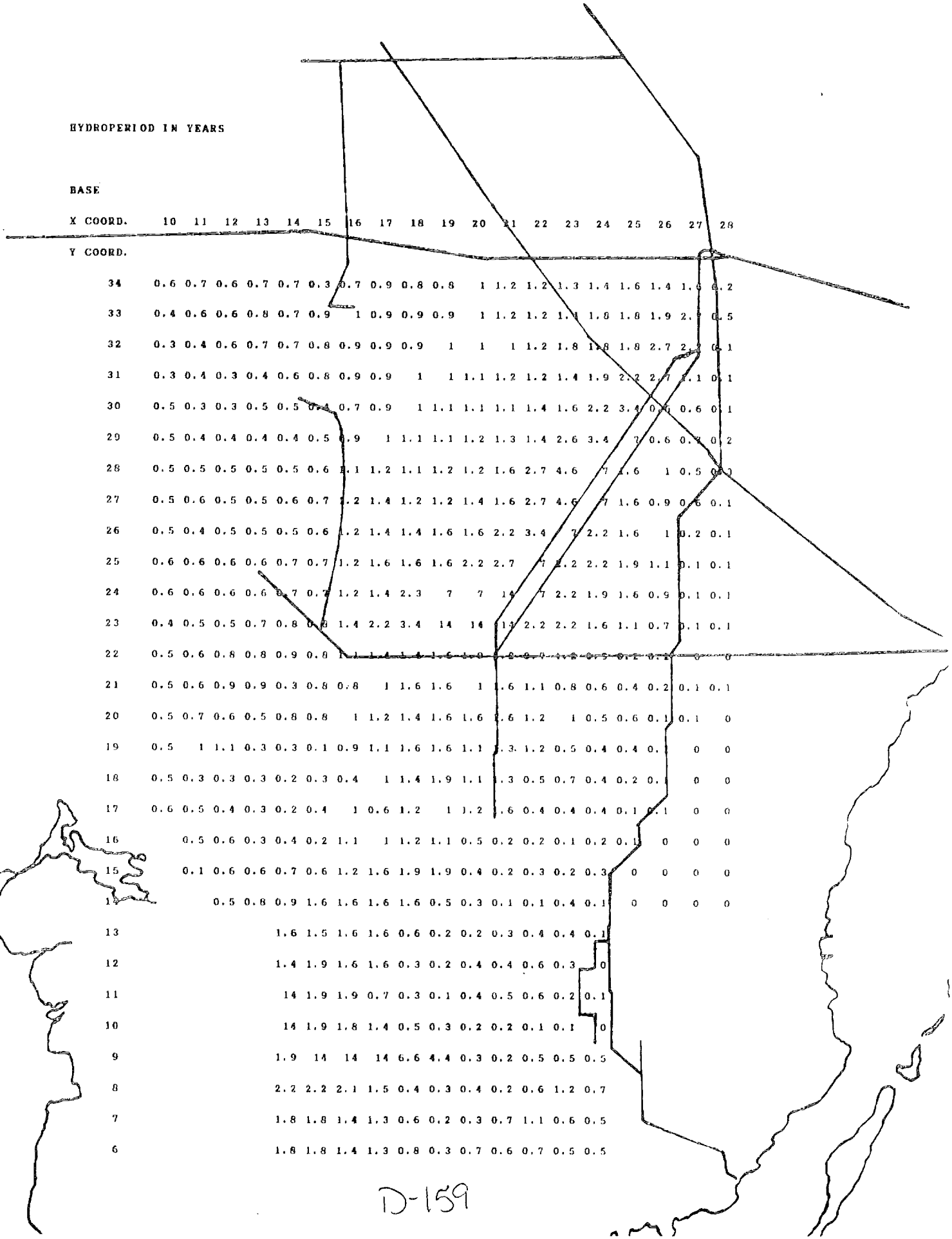
HYDROPERIOD IN YEARS

BASE

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.9	0.8	0.8	1	1.2	1.2	1.3	1.4	1.6	1.4	1.6	0.2
33	0.4	0.6	0.6	0.8	0.7	0.9	1	0.9	0.9	0.9	1	1.2	1.2	1.4	1.8	1.8	1.9	2.7	0.5
32	0.3	0.4	0.6	0.7	0.7	0.8	0.9	0.9	0.9	1	1	1	1.2	1.8	1.8	1.8	2.7	2.7	0.1
31	0.3	0.4	0.3	0.4	0.6	0.8	0.9	0.9	1	1	1.1	1.2	1.2	1.4	1.9	2.2	2.7	2.1	0.1
30	0.5	0.3	0.3	0.5	0.5	0.4	0.7	0.9	1	1.1	1.1	1.1	1.4	1.6	2.2	3.4	0.6	0.6	0.1
29	0.5	0.4	0.4	0.4	0.4	0.5	0.9	1	1.1	1.1	1.2	1.3	1.4	2.6	3.4	7	0.6	0.7	0.2
28	0.5	0.5	0.5	0.5	0.5	0.6	1.1	1.2	1.1	1.2	1.2	1.6	2.7	4.6	7	1.6	1	0.5	0.0
27	0.5	0.6	0.5	0.5	0.6	0.7	1.2	1.4	1.2	1.2	1.4	1.6	2.7	4.6	7	1.6	0.9	0.6	0.1
26	0.5	0.4	0.5	0.5	0.5	0.6	1.2	1.4	1.4	1.6	1.6	2.2	3.4	7	2.2	1.6	1	0.2	0.1
25	0.6	0.6	0.6	0.6	0.7	0.7	1.2	1.6	1.6	1.6	2.2	2.7	7	2.2	2.2	1.9	1.1	0.1	0.1
24	0.6	0.6	0.6	0.6	0.7	0.7	1.2	1.4	2.3	7	7	14	7	2.2	1.9	1.6	0.9	0.1	0.1
23	0.4	0.5	0.5	0.7	0.8	0.8	1.4	2.2	3.4	14	14	14	2.2	2.2	1.6	1.1	0.7	0.1	0.1
22	0.5	0.6	0.8	0.8	0.9	0.8	1	1.4	1.4	1.6	1.0	0.8	0.9	0.8	0.5	0.2	0.2	0	0
21	0.5	0.6	0.9	0.9	0.3	0.8	0.8	1	1.6	1.6	1	1.6	1.1	0.8	0.6	0.4	0.2	0.1	0.1
20	0.5	0.7	0.6	0.5	0.8	0.8	1	1.2	1.4	1.6	1.6	1.6	1.2	1	0.5	0.6	0.1	0.1	0
19	0.5	1	1.1	0.3	0.3	0.1	0.9	1.1	1.6	1.6	1.1	1.3	1.2	0.5	0.4	0.4	0.1	0	0
18	0.5	0.3	0.3	0.3	0.2	0.3	0.4	1	1.4	1.9	1.1	1.3	0.5	0.7	0.4	0.2	0.1	0	0
17	0.6	0.5	0.4	0.3	0.2	0.4	1	0.6	1.2	1	1.2	1.6	0.4	0.4	0.4	0.1	0.1	0	0
16		0.5	0.6	0.3	0.4	0.2	1.1	1	1.2	1.1	0.5	0.2	0.2	0.1	0.2	0.1	0	0	0
15		0.1	0.6	0.6	0.7	0.6	1.2	1.6	1.9	1.9	0.4	0.2	0.3	0.2	0.3	0	0	0	0
14			0.5	0.8	0.9	1.6	1.6	1.6	1.6	0.5	0.3	0.1	0.1	0.4	0.1	0	0	0	0
13					1.6	1.5	1.6	1.6	0.6	0.2	0.2	0.3	0.4	0.4	0.1				
12					1.4	1.9	1.6	1.6	0.3	0.2	0.4	0.4	0.6	0.3	0				
11					14	1.9	1.9	0.7	0.3	0.1	0.4	0.5	0.6	0.2	0.1				
10					14	1.9	1.8	1.4	0.5	0.3	0.2	0.2	0.1	0.1	0				
9					1.9	14	14	14	6.6	4.4	0.3	0.2	0.5	0.5	0.5				
8					2.2	2.2	2.1	1.5	0.4	0.3	0.4	0.2	0.6	1.2	0.7				
7					1.8	1.8	1.4	1.3	0.6	0.2	0.3	0.7	1.1	0.6	0.5				
6					1.8	1.8	1.4	1.3	0.8	0.3	0.7	0.6	0.7	0.5	0.5				

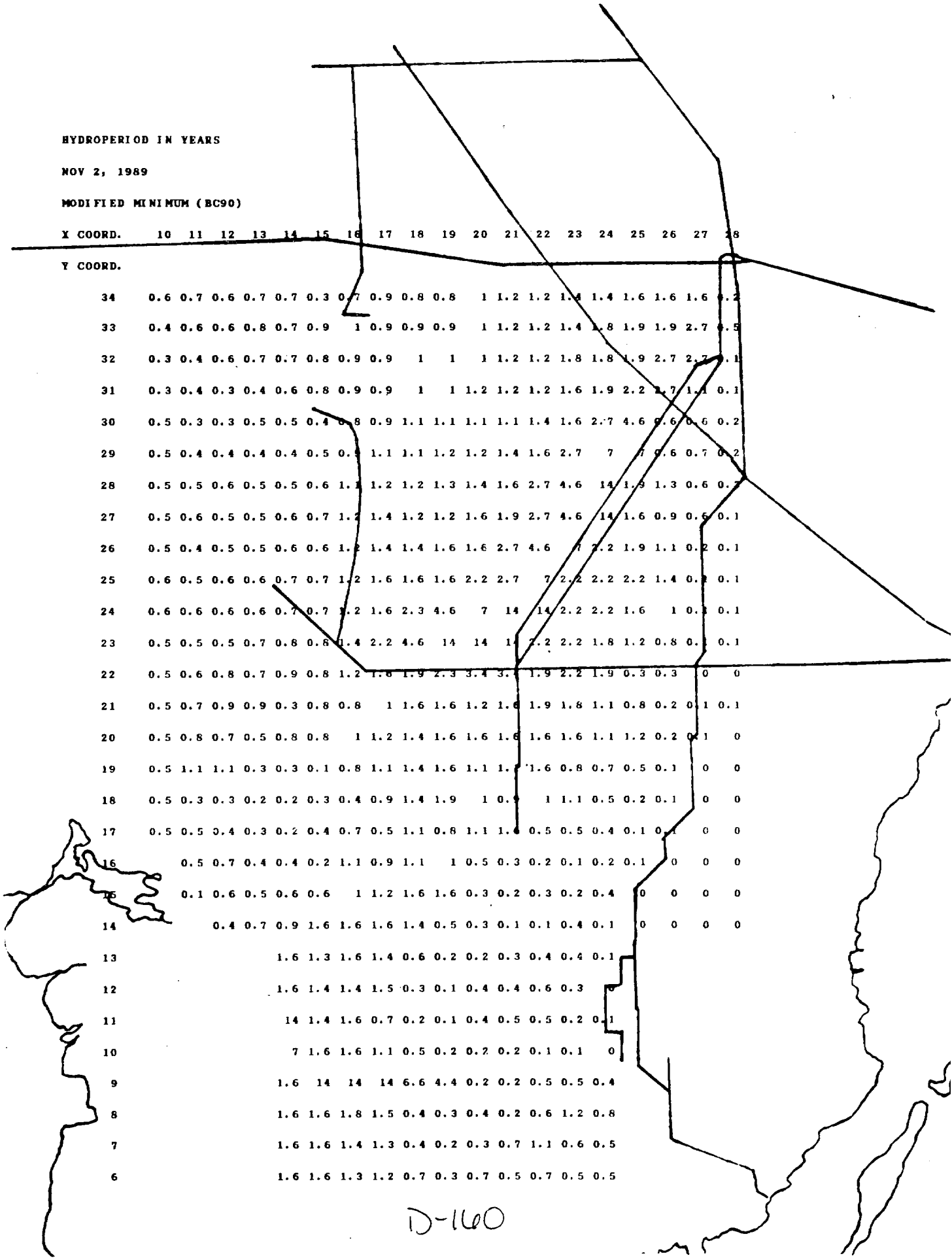


HYDROPERIOD IN YEARS

NOV 2, 1989

MODIFIED MINIMUM (BC90)

X COORD. / Y COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
34	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.9	0.8	0.8	1	1.2	1.2	1.4	1.4	1.6	1.6	1.6	0.2
33	0.4	0.6	0.6	0.8	0.7	0.9	1	0.9	0.9	0.9	1	1.2	1.2	1.4	1.8	1.9	1.9	2.7	0.5
32	0.3	0.4	0.6	0.7	0.7	0.8	0.9	0.9	1	1	1	1.2	1.2	1.8	1.8	1.9	2.7	2.7	0.1
31	0.3	0.4	0.3	0.4	0.6	0.8	0.9	0.9	1	1	1.2	1.2	1.2	1.6	1.9	2.2	2.7	1.1	0.1
30	0.5	0.3	0.3	0.5	0.5	0.4	0.8	0.9	1.1	1.1	1.1	1.1	1.4	1.6	2.7	4.6	0.6	0.6	0.2
29	0.5	0.4	0.4	0.4	0.4	0.5	0.9	1.1	1.1	1.2	1.2	1.4	1.6	2.7	7	7	0.6	0.7	0.2
28	0.5	0.5	0.6	0.5	0.5	0.6	1.1	1.2	1.2	1.3	1.4	1.6	2.7	4.6	14	1.9	1.3	0.6	0.7
27	0.5	0.6	0.5	0.5	0.6	0.7	1.2	1.4	1.2	1.2	1.6	1.9	2.7	4.6	14	1.6	0.9	0.6	0.1
26	0.5	0.4	0.5	0.5	0.6	0.6	1.2	1.4	1.4	1.6	1.6	2.7	4.6	7	2.2	1.9	1.1	0.2	0.1
25	0.6	0.5	0.6	0.6	0.7	0.7	1.2	1.6	1.6	1.6	2.2	2.7	7	2.2	2.2	2.2	1.4	0.1	0.1
24	0.6	0.6	0.6	0.6	0.7	0.7	1.2	1.6	2.3	4.6	7	14	14	2.2	2.2	1.6	1	0.1	0.1
23	0.5	0.5	0.5	0.7	0.8	0.8	1.4	2.2	4.6	14	14	14	2.2	2.2	1.8	1.2	0.8	0.1	0.1
22	0.5	0.6	0.8	0.7	0.9	0.8	1.2	1.6	1.9	2.3	3.4	3.4	1.9	2.2	1.9	0.3	0.3	0	0
21	0.5	0.7	0.9	0.9	0.3	0.8	0.8	1	1.6	1.6	1.2	1.6	1.9	1.8	1.1	0.8	0.2	0.1	0.1
20	0.5	0.8	0.7	0.5	0.8	0.8	1	1.2	1.4	1.6	1.6	1.6	1.6	1.6	1.1	1.2	0.2	0.1	0
19	0.5	1.1	1.1	0.3	0.3	0.1	0.8	1.1	1.4	1.6	1.1	1.2	1.6	0.8	0.7	0.5	0.1	0	0
18	0.5	0.3	0.3	0.2	0.2	0.3	0.4	0.9	1.4	1.9	1	0.9	1	1.1	0.5	0.2	0.1	0	0
17	0.5	0.5	0.4	0.3	0.2	0.4	0.7	0.5	1.1	0.8	1.1	1.6	0.5	0.5	0.4	0.1	0.1	0	0
16		0.5	0.7	0.4	0.4	0.2	1.1	0.9	1.1	1	0.5	0.3	0.2	0.1	0.2	0.1	0	0	0
15		0.1	0.6	0.5	0.6	0.6	1	1.2	1.6	1.6	0.3	0.2	0.3	0.2	0.4	0	0	0	0
14			0.4	0.7	0.9	1.6	1.6	1.6	1.4	0.5	0.3	0.1	0.1	0.4	0.1	0	0	0	0
13					1.6	1.3	1.6	1.4	0.6	0.2	0.2	0.3	0.4	0.4	0.1				
12					1.6	1.4	1.4	1.5	0.3	0.1	0.4	0.4	0.6	0.3	0				
11					14	1.4	1.6	0.7	0.2	0.1	0.4	0.5	0.5	0.2	0.1				
10					7	1.6	1.6	1.1	0.5	0.2	0.2	0.2	0.1	0.1	0				
9					1.6	14	14	14	6.6	4.4	0.2	0.2	0.5	0.5	0.4				
8					1.6	1.6	1.8	1.5	0.4	0.3	0.4	0.2	0.6	1.2	0.8				
7					1.6	1.6	1.4	1.3	0.4	0.2	0.3	0.7	1.1	0.6	0.5				
6					1.6	1.6	1.3	1.2	0.7	0.3	0.7	0.5	0.7	0.5	0.5				



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HYDROPERIOD IN YEARS

NOV 2, 1989

BASIC RAINDRIVEN (MU90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.9	0.8	0.8	1	1.2	1.4	1.3	1.4	1.6	1.9	3.4	0.2
33	0.4	0.6	0.6	0.8	0.7	0.9	1	0.9	0.9	0.9	1	1.2	1.4	1.4	1.6	1.9	2.7	4.6	0.7
32	0.3	0.5	0.5	0.7	0.7	0.8	0.9	0.8	0.9	0.9	1	1.2	1.2	1.6	1.6	2.2	3.4	4.6	0.1
31	0.3	0.4	0.3	0.4	0.6	0.8	0.8	0.9	1.1	1.1	1.1	1.2	1.4	1.6	2.2	2.7	4.6	1.1	0.1
30	0.5	0.3	0.3	0.5	0.5	0.4	0.7	0.9	1.2	1.2	1.2	1.4	1.6	1.6	2.7	4.6	0.7	0.8	0.1
29	0.5	0.4	0.4	0.4	0.4	0.5	1.2	1.2	1.4	1.2	1.2	1.6	1.6	2.2	2.7	2.3	0.6	0.7	0.2
28	0.5	0.5	0.6	0.5	0.5	0.6	1.2	1.4	1.4	1.6	1.6	1.6	2.2	2.7	2.7	1.9	1.3	0.6	0.3
27	0.5	0.6	0.5	0.5	0.6	0.7	1.4	1.6	1.6	1.4	1.9	2.2	2.2	2.7	2.7	1.6	1.3	0.7	0.2
26	0.5	0.4	0.5	0.5	0.5	0.6	1.4	1.9	1.9	1.9	2.2	2.2	2.7	2.3	2.2	1.6	1.2	0.2	0.1
25	0.6	0.5	0.6	0.6	0.8	0.7	1.4	1.9	2.2	2.2	2.2	2.2	2.2	2.7	1.9	1.9	1.2	0.1	0.1
24	0.5	0.5	0.6	0.6	0.7	0.7	1.4	1.6	1.8	1.6	1.6	2.2	2.2	2.7	1.1	1.6	0.9	0.1	0.1
23	0.4	0.4	0.6	0.7	0.8	0.7	1.4	1.5	1.5	1.6	2.2	2.7	2.3	2.7	1.6	1.4	0.7	0.1	0.1
22	0.5	0.6	0.7	0.8	0.7	0.5	1.2	1.6	1.6	1.8	2.2	2.2	2.2	2.2	2.2	0.5	0.5	0	0.1
21	0.5	0.6	0.8	0.8	0.3	0.6	0.8	1.1	1.6	1.6	1.1	1.6	2.2	1.8	1.8	1.5	0.5	0.2	0.1
20	0.6	0.7	0.7	0.5	0.6	0.5	0.8	1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.4	0.3	0.1	0
19	0.5	0.8	0.7	0.1	0.3	0.2	0.6	0.8	1.4	1.6	1.1	1.5	1.6	1.2	1	0.5	0.1	0	0
18	0.5	0.3	0.3	0.4	0.2	0.3	0.3	0.6	1.4	1.6	1	1	1.1	1.4	0.5	0.1	0	0	0
17	0.5	0.5	0.3	0.3	0.2	0.3	0.6	0.5	0.9	0.8	1.2	1.4	0.6	0.6	0.5	0.1	0	0	0
16		0.5	0.6	0.3	0.6	0.3	1	0.9	0.9	0.9	0.5	0.3	0.2	0.2	0.2	0.1	0	0	0
15		0.1	0.6	0.6	0.6	0.5	0.9	0.9	1.6	1.6	0.5	0.2	0.4	0.2	0.2	0	0	0	0
14			0.5	0.7	0.8	1.4	1.4	1.2	1.2	0.6	0.3	0.1	0.2	0.4	0.1	0	0	0	0
13					1.4	1.1	1.6	1.1	0.6	0.3	0.2	0.3	0.4	0.4	0.1				
12					1.6	1.4	1.4	1.3	0.4	0.2	0.4	0.4	0.6	0.3					
11					7	1.4	1.6	0.7	0.2	0.1	0.4	0.5	0.6	0.2	0.1				
10					4.6	1.6	1.6	1	0.5	0.3	0.2	0.2	0.1	0.1	0				
9					1.6	14	14	14	6.6	4.4	0.2	0.2	0.5	0.5	0.5				
8					1.5	1.6	1.5	1.3	0.4	0.3	0.4	0.2	0.6	1.4	0.7				
7					1.5	1.4	1.4	1.3	0.5	0.2	0.3	0.7	1.2	0.6	0.5				
6					1.6	1.4	1.3	1.2	0.7	0.3	0.7	0.6	0.7	0.5	0.5				

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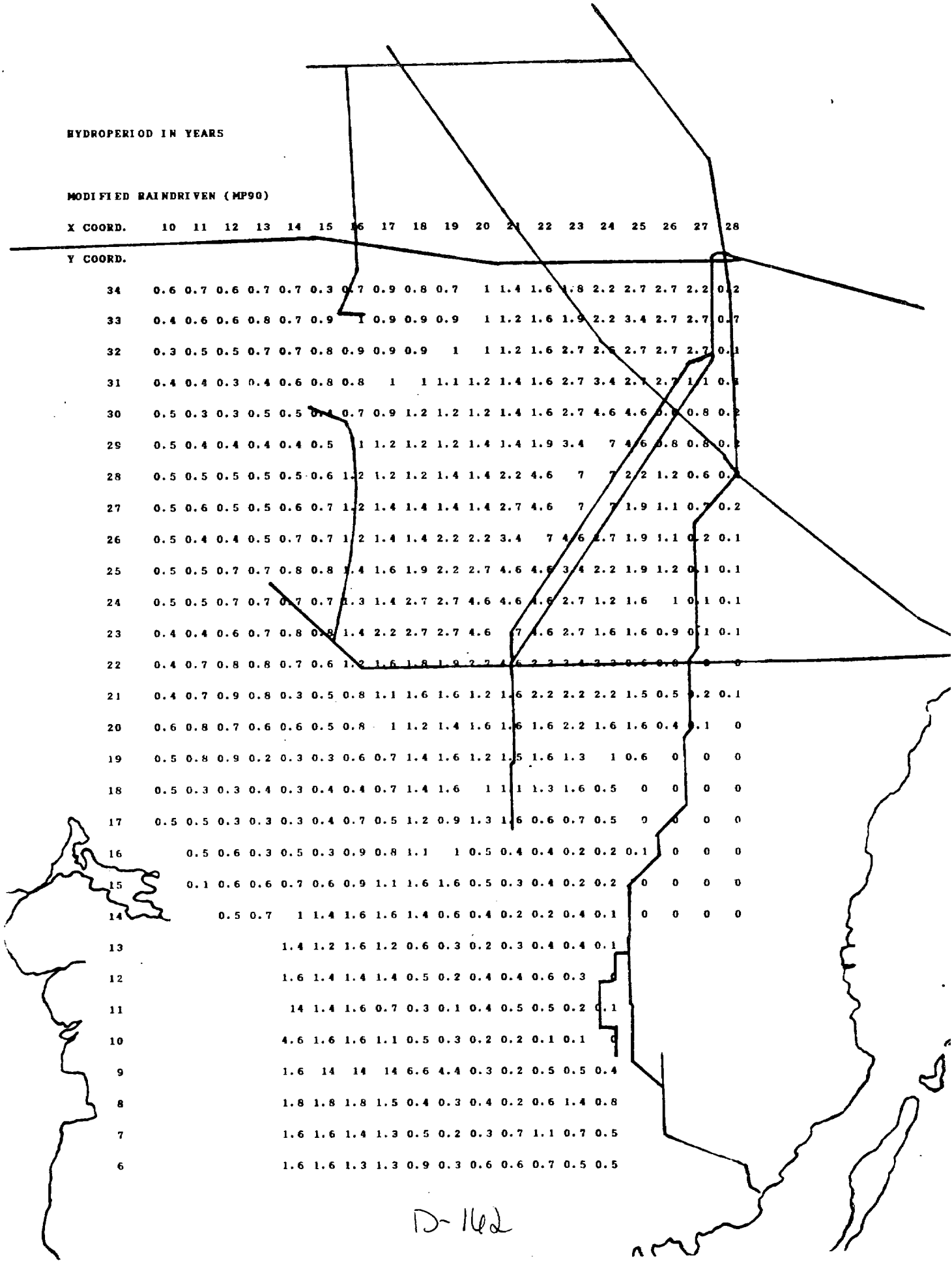
HYDROPERIOD IN YEARS

MODIFIED RAINDRIVEN (MP90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.9	0.8	0.7	1	1.4	1.6	1.8	2.2	2.7	2.7	2.2	0.2
33	0.4	0.6	0.6	0.8	0.7	0.9	1	0.9	0.9	0.9	1	1.2	1.6	1.9	2.2	3.4	2.7	2.7	0.7
32	0.3	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.9	1	1	1.2	1.6	2.7	2.7	2.7	2.7	2.7	0.1
31	0.4	0.4	0.3	0.4	0.6	0.8	0.8	1	1	1.1	1.2	1.4	1.6	2.7	3.4	2.7	2.7	1.1	0.1
30	0.5	0.3	0.3	0.5	0.5	0.4	0.7	0.9	1.2	1.2	1.2	1.4	1.6	2.7	4.6	4.6	0.8	0.8	0.2
29	0.5	0.4	0.4	0.4	0.4	0.5	1	1.2	1.2	1.2	1.4	1.4	1.9	3.4	7	4.6	0.8	0.8	0.2
28	0.5	0.5	0.5	0.5	0.5	0.6	1.2	1.2	1.2	1.4	1.4	2.2	4.6	7	7	2.2	1.2	0.6	0.2
27	0.5	0.6	0.5	0.5	0.6	0.7	1.2	1.4	1.4	1.4	1.4	2.7	4.6	7	7	1.9	1.1	0.7	0.2
26	0.5	0.4	0.4	0.5	0.7	0.7	1.2	1.4	1.4	2.2	2.2	3.4	7	4.6	2.7	1.9	1.1	0.2	0.1
25	0.5	0.5	0.7	0.7	0.8	0.8	1.4	1.6	1.9	2.2	2.7	4.6	4.6	3.4	2.2	1.9	1.2	0.1	0.1
24	0.5	0.5	0.7	0.7	0.7	0.7	1.3	1.4	2.7	2.7	4.6	4.6	4.6	2.7	1.2	1.6	1	0.1	0.1
23	0.4	0.4	0.6	0.7	0.8	0.8	1.4	2.2	2.7	2.7	4.6	7	4.6	2.7	1.6	1.6	0.9	0.1	0.1
22	0.4	0.7	0.8	0.8	0.7	0.6	1.2	1.6	1.8	1.9	2.2	4.6	2.2	2.2	2.2	2.2	0.6	0.6	0
21	0.4	0.7	0.9	0.8	0.3	0.5	0.8	1.1	1.6	1.6	1.2	1.6	2.2	2.2	2.2	1.5	0.5	0.2	0.1
20	0.6	0.8	0.7	0.6	0.6	0.5	0.8	1	1.2	1.4	1.6	1.6	1.6	2.2	1.6	1.6	0.4	0.1	0
19	0.5	0.8	0.9	0.2	0.3	0.3	0.6	0.7	1.4	1.6	1.2	1.5	1.6	1.3	1	0.6	0	0	0
18	0.5	0.3	0.3	0.4	0.3	0.4	0.4	0.7	1.4	1.6	1	1	1.3	1.6	0.5	0	0	0	0
17	0.5	0.5	0.3	0.3	0.3	0.4	0.7	0.5	1.2	0.9	1.3	1.6	0.6	0.7	0.5	0	0	0	0
16		0.5	0.6	0.3	0.5	0.3	0.9	0.8	1.1	1	0.5	0.4	0.4	0.2	0.2	0.1	0	0	0
15		0.1	0.6	0.6	0.7	0.6	0.9	1.1	1.6	1.6	0.5	0.3	0.4	0.2	0.2	0	0	0	0
14			0.5	0.7	1	1.4	1.6	1.6	1.4	0.6	0.4	0.2	0.2	0.4	0.1	0	0	0	0
13					1.4	1.2	1.6	1.2	0.6	0.3	0.2	0.3	0.4	0.4	0.1				
12					1.6	1.4	1.4	1.4	0.5	0.2	0.4	0.4	0.6	0.3	0				
11					14	1.4	1.6	0.7	0.3	0.1	0.4	0.5	0.5	0.2	0.1				
10					4.6	1.6	1.6	1.1	0.5	0.3	0.2	0.2	0.1	0.1	0				
9					1.6	14	14	14	6.6	4.4	0.3	0.2	0.5	0.5	0.4				
8					1.8	1.8	1.8	1.5	0.4	0.3	0.4	0.2	0.6	1.4	0.8				
7					1.6	1.6	1.4	1.3	0.5	0.2	0.3	0.7	1.1	0.7	0.5				
6					1.6	1.6	1.3	1.3	0.9	0.3	0.6	0.6	0.7	0.5	0.5				

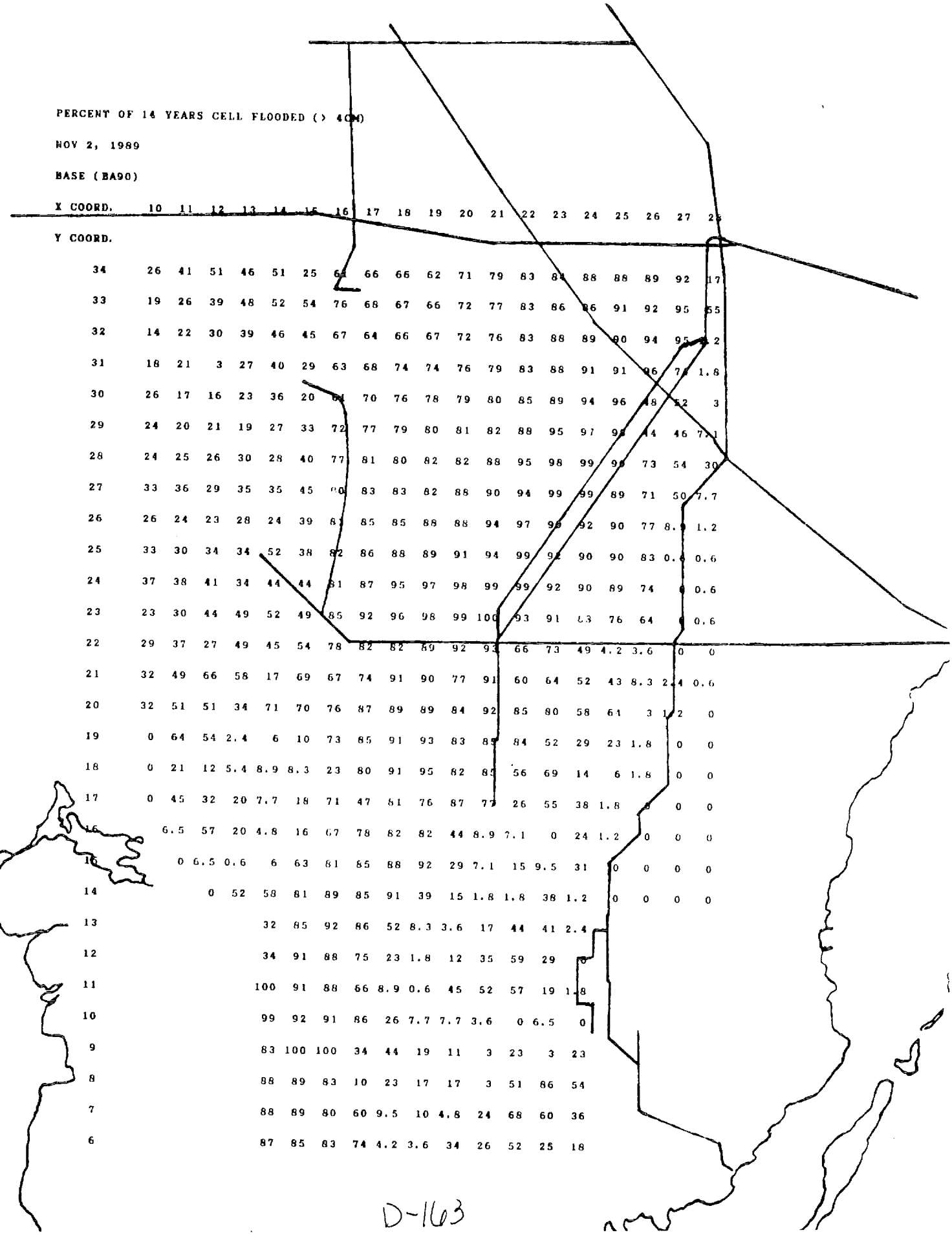


PERCENT OF 14 YEARS CELL FLOODED (> 4CM)

NOV 2, 1989

BASE (BA90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	26	41	51	46	51	25	64	66	66	62	71	79	83	84	88	88	89	92	17
33	19	26	39	48	52	54	76	68	67	66	72	77	83	86	86	91	92	95	55
32	14	22	30	39	46	45	67	64	66	67	72	76	83	88	89	90	94	95	2
31	18	21	3	27	40	29	63	68	74	74	76	79	83	88	91	91	96	76	1.8
30	26	17	16	23	36	20	64	70	76	78	79	80	85	89	94	96	48	52	3
29	24	20	21	19	27	33	72	77	79	80	81	82	88	95	97	98	44	46	7.1
28	24	25	26	30	28	40	77	81	80	82	82	88	95	98	99	98	73	54	30
27	33	36	29	35	35	45	80	83	83	82	88	90	94	99	99	89	71	50	7.7
26	26	24	23	28	24	39	81	85	85	88	88	94	97	98	92	90	77	8.9	1.2
25	33	30	34	34	52	38	82	86	88	89	91	94	99	98	90	90	83	0.6	0.6
24	37	38	41	34	44	44	81	87	95	97	98	99	99	92	90	89	74	0	0.6
23	23	30	44	49	52	49	85	92	96	98	99	100	93	91	83	76	64	0	0.6
22	29	37	27	49	45	54	78	82	82	89	92	93	66	73	49	4.2	3.6	0	0
21	32	49	66	58	17	69	67	74	91	90	77	91	60	64	52	43	8.3	2.4	0.6
20	32	51	51	34	71	70	76	87	89	89	84	92	85	80	58	61	3	1.2	0
19	0	64	54	2.4	6	10	73	85	91	93	83	85	84	52	29	23	1.8	0	0
18	0	21	12	5.4	8.9	8.3	23	80	91	95	82	85	56	69	14	6	1.8	0	0
17	0	45	32	20	7.7	18	71	47	81	76	87	77	26	55	38	1.8	0	0	0
16		6.5	57	20	4.8	16	67	78	82	82	44	8.9	7.1	0	24	1.2	0	0	0
15		0	6.5	0.6	6	63	81	85	88	92	29	7.1	15	9.5	31	0	0	0	0
14			0	52	58	81	89	85	91	39	15	1.8	1.8	38	1.2	0	0	0	0
13					32	85	92	86	52	8.3	3.6	17	44	41	2.4				
12					34	91	88	75	23	1.8	12	35	59	29	0				
11					100	91	88	66	8.9	0.6	45	52	57	19	1.8				
10					99	92	91	86	26	7.7	7.7	3.6	0	6.5	0				
9					83	100	100	34	44	19	11	3	23	3	23				
8					88	89	83	10	23	17	17	3	51	86	54				
7					88	89	80	60	9.5	10	4.8	24	68	60	36				
6					87	85	83	74	4.2	3.6	34	26	52	25	18				



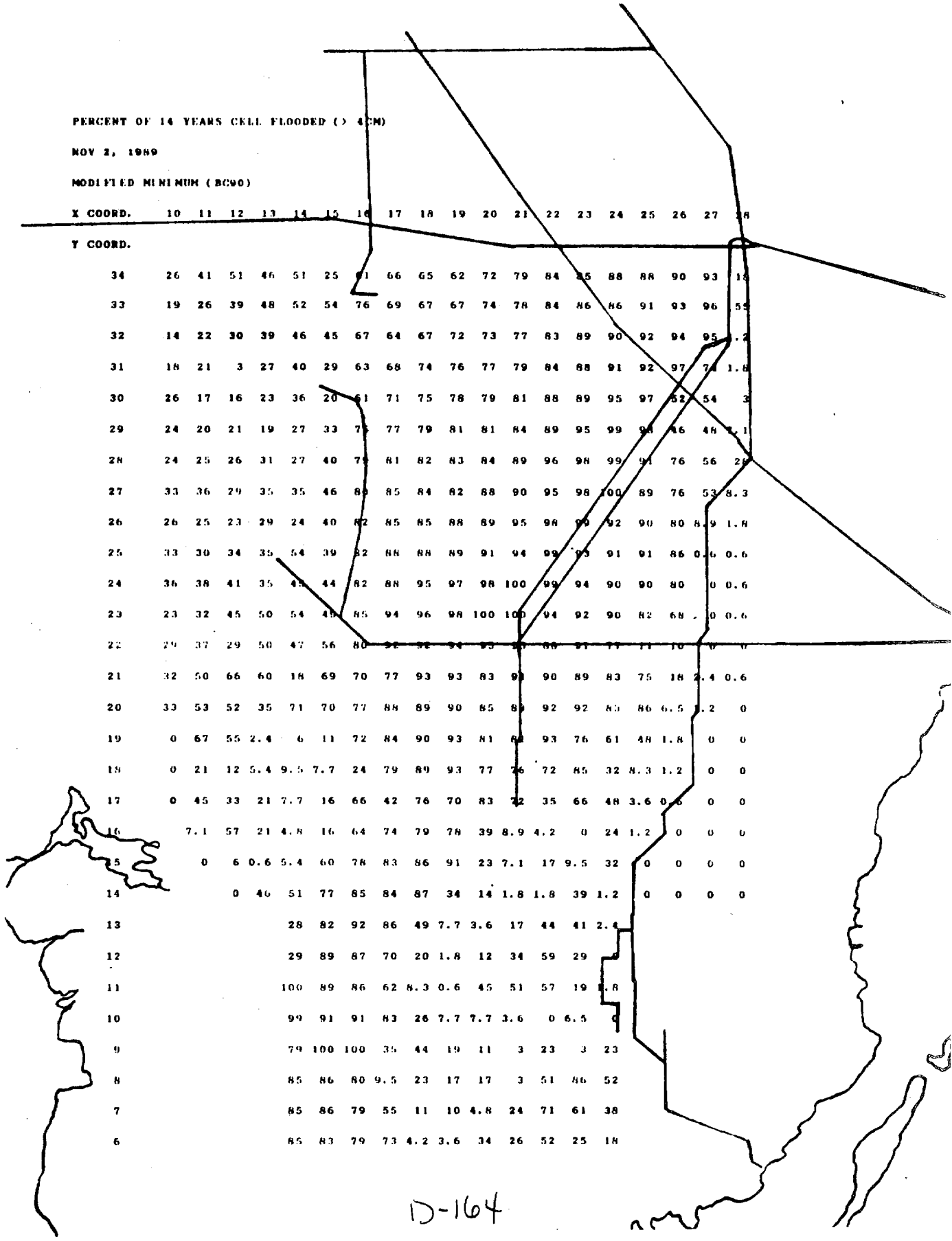
D-163

PERCENT OF 14 YEARS CELL FLOODED (> 4CM)

NOV 2, 1989

MODIFIED MINIMUM (BC90)

Y COORD. \ X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
34	26	41	51	46	51	25	61	66	65	62	72	79	84	85	88	88	90	93	18
33	19	26	39	48	52	54	76	69	67	67	74	78	84	86	86	91	93	96	55
32	14	22	30	39	46	45	67	64	67	72	73	77	83	89	90	92	94	95	1.2
31	18	21	3	27	40	29	63	68	74	76	77	79	84	88	91	92	97	74	1.8
30	26	17	16	23	36	20	61	71	75	78	79	81	88	89	95	97	52	54	3
29	24	20	21	19	27	33	75	77	79	81	81	84	89	95	99	98	46	48	1.1
28	24	25	26	31	27	40	79	81	82	83	84	89	96	98	99	91	76	56	26
27	33	36	29	35	35	46	89	85	84	82	88	90	95	98	100	89	76	53	8.3
26	26	25	23	29	24	40	82	85	85	88	89	95	98	99	92	90	80	8.9	1.8
25	33	30	34	35	54	39	82	88	88	89	91	94	99	93	91	91	86	0.6	0.6
24	36	38	41	35	45	44	82	88	95	97	98	100	99	94	90	90	80	0	0.6
23	23	32	45	50	54	49	85	94	96	98	100	100	94	92	90	82	68	0	0.6
22	29	37	29	50	47	56	80	92	92	94	95	99	88	91	77	71	10	0	0
21	32	50	66	60	18	69	70	77	93	93	83	99	90	89	83	75	18	2.4	0.6
20	33	53	52	35	71	70	77	88	89	90	85	89	92	92	85	86	6.5	1.2	0
19	0	67	55	2.4	6	11	72	84	90	93	81	88	93	76	61	48	1.8	0	0
18	0	21	12	5.4	9.5	7.7	24	79	89	93	77	76	72	85	32	8.3	1.2	0	0
17	0	45	33	21	7.7	16	66	42	76	70	83	72	35	66	48	3.6	0.6	0	0
16		7.1	57	21	4.8	16	64	74	79	78	39	8.9	4.2	0	24	1.2	0	0	0
15		0	6	0.6	5.4	60	78	83	86	91	23	7.1	17	9.5	32	0	0	0	0
14			0	46	51	77	85	84	87	34	14	1.8	1.8	39	1.2	0	0	0	0
13					28	82	92	86	49	7.7	3.6	17	44	41	2.4				
12					29	89	87	70	20	1.8	12	34	59	29	0				
11					100	89	86	62	8.3	0.6	45	51	57	19	1.8				
10					99	91	91	83	26	7.7	7.7	3.6	0	6.5	0				
9					79	100	100	35	44	19	11	3	23	3	23				
8					85	86	80	9.5	23	17	17	3	51	86	52				
7					85	86	79	55	11	10	4.8	24	71	61	38				
6					85	83	79	73	4.2	3.6	34	26	52	25	18				



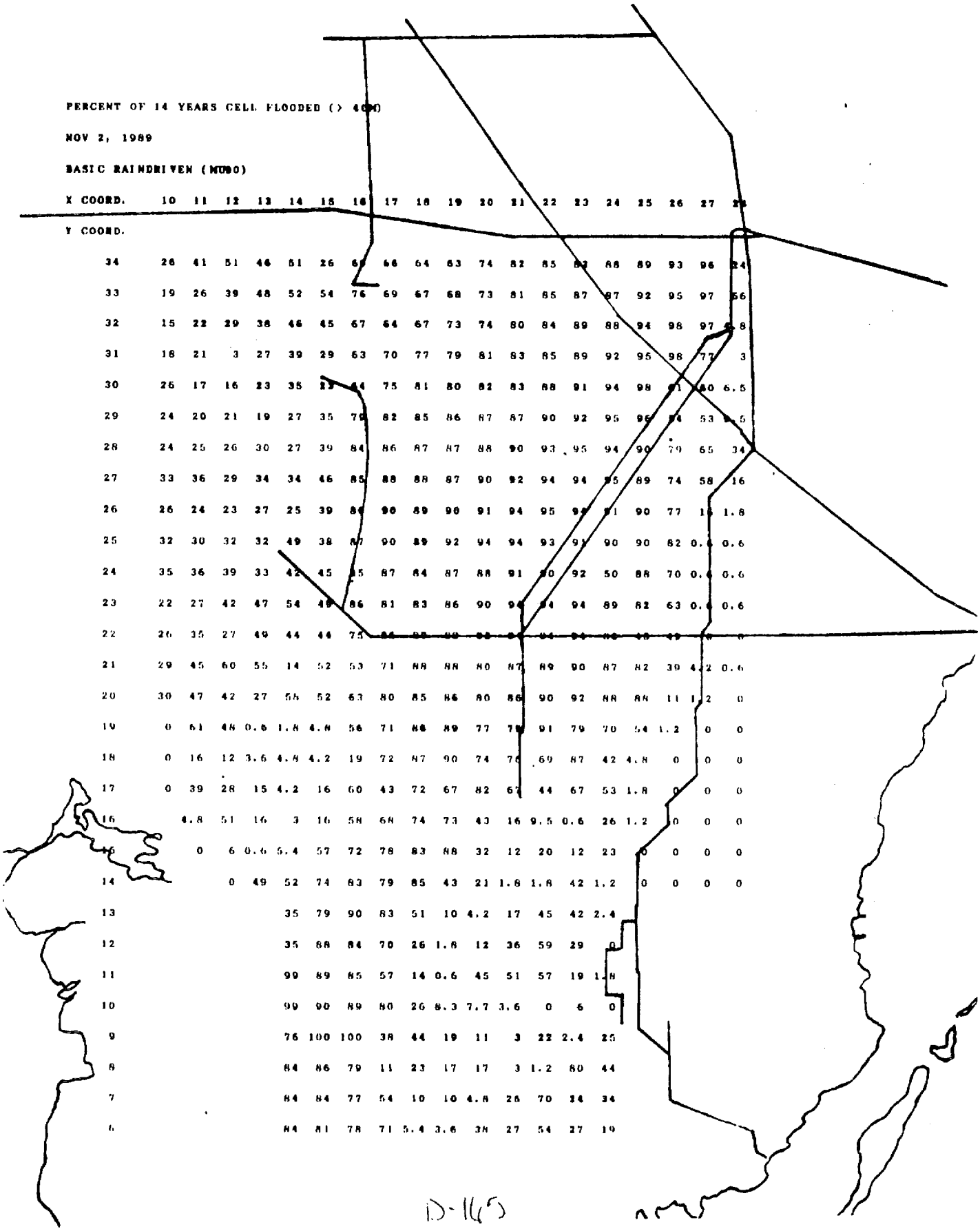
D-164

PERCENT OF 14 YEARS CELL FLOODED (> 4[illegible])

NOV 2, 1989

BASIC RAINDRIVEN (MUSO)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	26	41	51	46	51	26	6[illegible]	66	64	63	74	82	85	8[illegible]	88	89	93	96	24
33	19	26	39	48	52	54	76	69	67	68	73	81	85	87	87	92	95	97	56
32	15	22	29	38	46	45	67	64	67	73	74	80	84	89	88	94	98	97	[illegible].8
31	18	21	3	27	39	29	63	70	77	79	81	83	85	89	92	95	98	77	3
30	26	17	16	23	35	[illegible]	44	75	81	80	82	83	88	91	94	98	[illegible]	[illegible]0	6.5
29	24	20	21	19	27	35	79	82	85	86	87	87	90	92	95	96	[illegible]	53	[illegible].5
28	24	25	26	30	27	39	84	86	87	87	88	90	93	95	94	90	79	65	34
27	33	36	29	34	34	46	85	88	88	87	90	92	94	94	95	89	74	58	16
26	26	24	23	27	25	39	8[illegible]	90	89	90	91	94	95	9[illegible]	[illegible]1	90	77	1[illegible]	1.8
25	32	30	32	32	49	38	8[illegible]	90	89	92	94	94	93	91	90	90	82	0.[illegible]	0.6
24	35	36	39	33	42	45	85	87	84	87	88	91	[illegible]0	92	50	88	70	0.[illegible]	0.6
23	22	27	42	47	54	4[illegible]	86	81	83	86	90	9[illegible]	[illegible]4	94	89	82	63	0.[illegible]	0.6
22	26	35	27	49	44	44	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
21	29	45	60	55	14	52	53	71	88	88	80	87	89	90	87	82	39	4.2	0.6
20	30	47	42	27	56	52	63	80	85	86	80	86	90	92	88	88	11	1.2	0
19	0	61	48	0.6	1.8	4.8	56	71	86	89	77	7[illegible]	91	79	70	54	1.2	0	0
18	0	16	12	3.6	4.8	4.2	19	72	87	90	74	76	69	87	42	4.8	0	0	0
17	0	39	28	15	4.2	16	60	43	72	67	82	67	44	67	53	1.8	0	0	0
16		4.8	51	16	3	16	58	68	74	73	43	16	9.5	0.6	26	1.2	0	0	0
15		0	6	0.6	5.4	57	72	78	83	88	32	12	20	12	23	0	0	0	0
14			0	49	52	74	83	79	85	43	21	1.8	1.8	42	1.2	0	0	0	0
13					35	79	90	83	51	10	4.2	17	45	42	2.4				
12					35	88	84	70	26	1.8	12	36	59	29	0				
11					99	89	85	57	14	0.6	45	51	57	19	1.8				
10					99	90	89	80	26	8.3	7.7	3.6	0	6	0				
9					76	100	100	38	44	19	11	3	22	2.4	25				
8					84	86	79	11	23	17	17	3	1.2	80	44				
7					84	84	77	54	10	10	4.8	26	70	34	34				
6					84	81	78	71	5.4	3.6	38	27	54	27	19				



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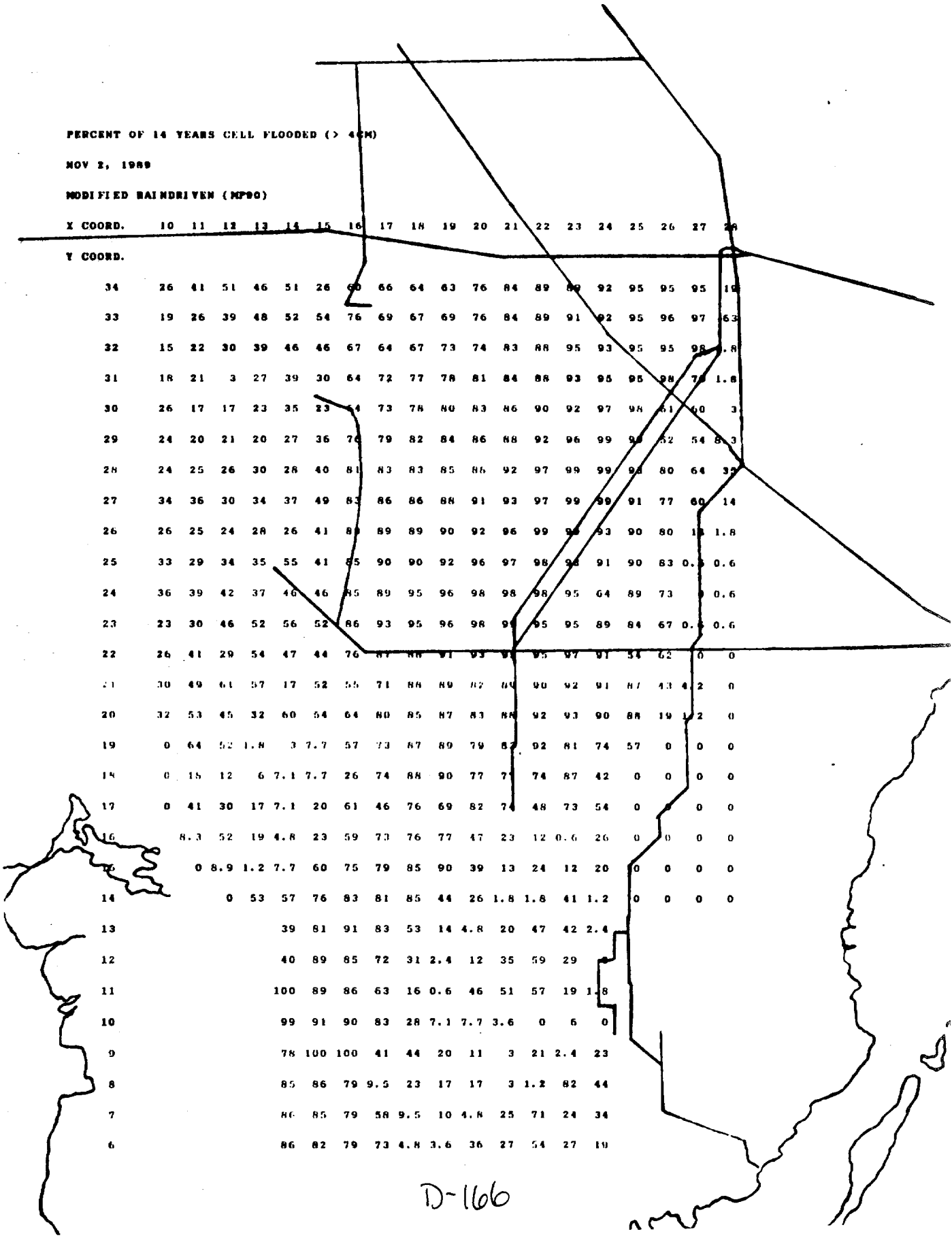
PERCENT OF 14 YEARS CELL FLOODED (> 4CM)

NOV 2, 1989

MODIFIED RAINDRIVEN (MP90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	26	41	51	46	51	26	60	66	64	63	76	84	89	89	92	95	95	95	19
33	19	26	39	48	52	54	76	69	67	69	76	84	89	91	92	95	96	97	63
32	15	22	30	39	46	46	67	64	67	73	74	83	88	95	93	95	95	98	1.8
31	18	21	3	27	39	30	64	72	77	78	81	84	88	93	95	95	98	78	1.8
30	26	17	17	23	35	23	54	73	78	80	83	86	90	92	97	98	81	60	3
29	24	20	21	20	27	36	76	79	82	84	86	88	92	96	99	98	52	54	8.3
28	24	25	26	30	28	40	81	83	83	85	86	92	97	99	99	98	80	64	32
27	34	36	30	34	37	49	83	86	86	88	91	93	97	99	99	91	77	60	14
26	26	25	24	28	26	41	84	89	89	90	92	96	99	98	93	90	80	18	1.8
25	33	29	34	35	55	41	85	90	90	92	96	97	98	98	91	90	83	0.6	0.6
24	36	39	42	37	46	46	85	89	95	96	98	98	98	95	64	89	73	0	0.6
23	23	30	46	52	56	52	86	93	95	96	98	98	95	95	89	84	67	0.6	0.6
22	26	41	29	54	47	44	76	87	88	91	93	98	95	97	91	54	62	0	0
21	30	49	61	57	17	52	55	71	88	89	82	80	90	92	91	87	43	4.2	0
20	32	53	45	32	60	54	64	80	85	87	83	88	92	93	90	88	19	1.2	0
19	0	64	52	1.8	3	7.7	57	73	87	89	79	87	92	81	74	57	0	0	0
18	0	15	12	6	7.1	7.7	26	74	88	90	77	71	74	87	42	0	0	0	0
17	0	41	30	17	7.1	20	61	46	76	69	82	74	48	73	54	0	0	0	0
16		8.3	52	19	4.8	23	59	73	76	77	47	23	12	0.6	26	0	0	0	0
15		0	8.9	1.2	7.7	60	75	79	85	90	39	13	24	12	20	0	0	0	0
14			0	53	57	76	83	81	85	44	26	1.8	1.8	41	1.2	0	0	0	0
13					39	81	91	83	53	14	4.8	20	47	42	2.4				
12					40	89	85	72	31	2.4	12	35	59	29					
11					100	89	86	63	16	0.6	46	51	57	19	1.8				
10					99	91	90	83	28	7.1	7.7	3.6	0	6	0				
9					78	100	100	41	44	20	11	3	21	2.4	23				
8					85	86	79	9.5	23	17	17	3	1.2	82	44				
7					86	85	79	58	9.5	10	4.8	25	71	24	34				
6					86	82	79	73	4.8	3.6	36	27	54	27	19				



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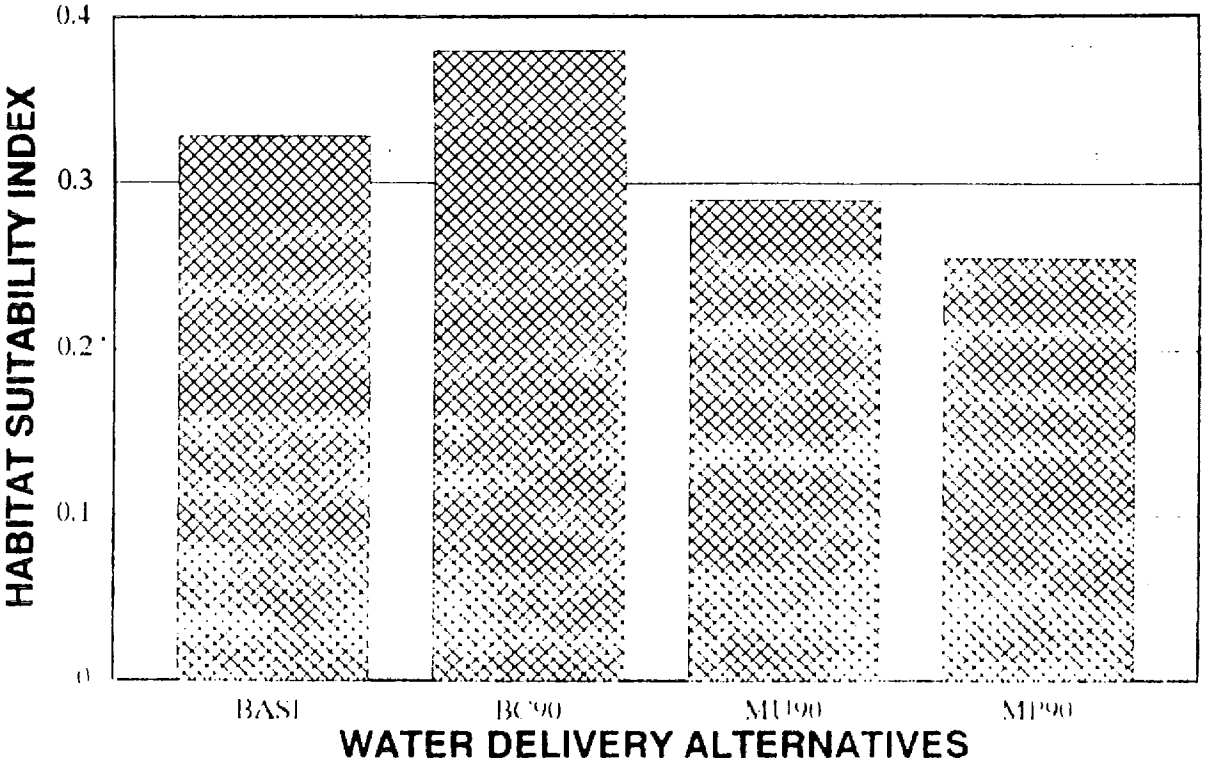
HABITAT SUITABILITY FOR WOOD STORKS



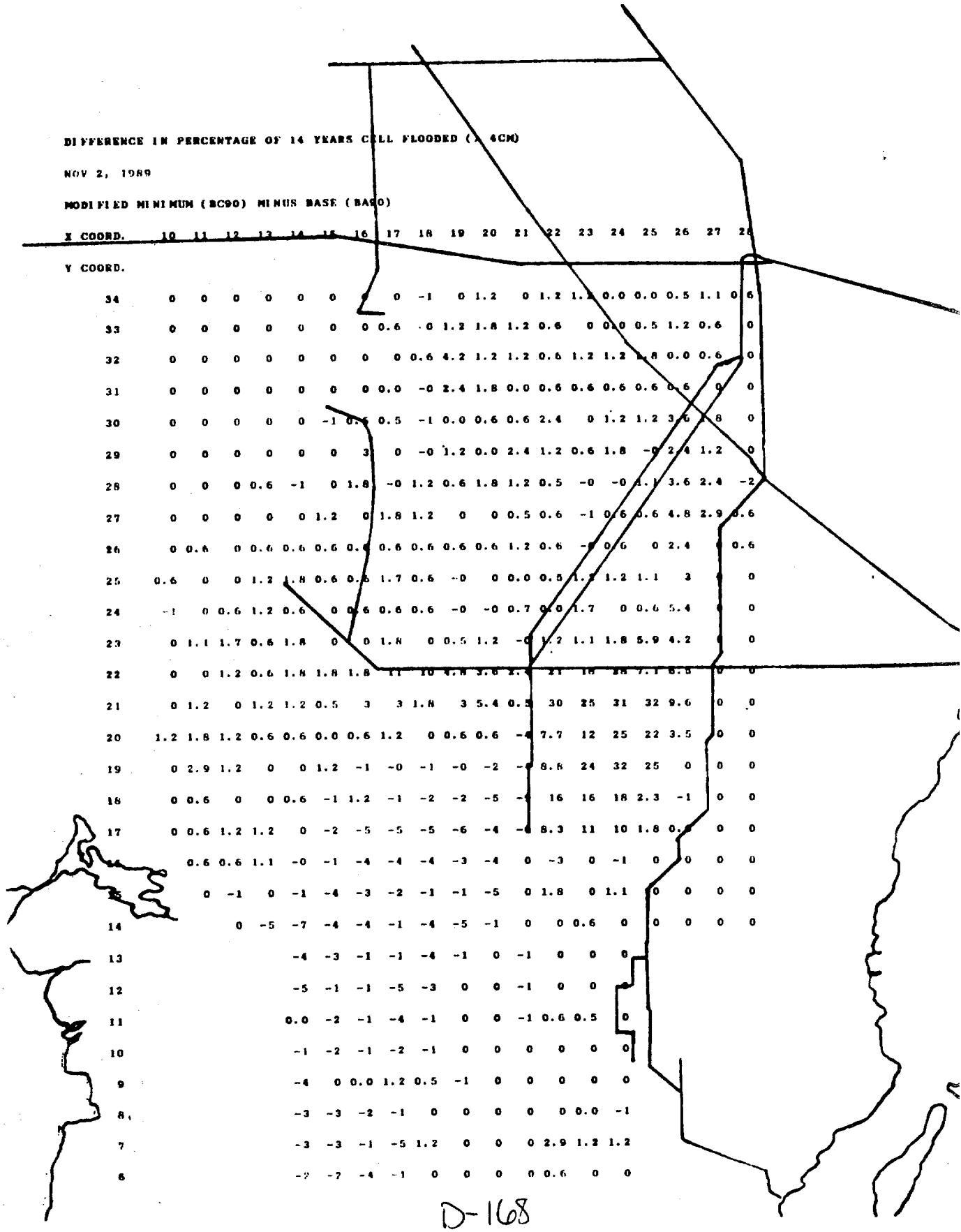
ALTERNATIVES AS OF 11/7/89
BASED ON WOOD STORK NESTING SUCCESS MODEL

DIFFERENCE IN PERCENTAGE OF 14 YEARS CELL FLOODED (> 4CM)

NOV 2, 1989

MODIFIED MINIMUM (BC90) MINUS BASE (BA90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0	0	0	0	0	0	0	0	-1	0	1.2	0	1.2	1.2	0.0	0.0	0.5	1.1	0.6
33	0	0	0	0	0	0	0	0.6	0	1.2	1.8	1.2	0.6	0	0.0	0.5	1.2	0.6	0
32	0	0	0	0	0	0	0	0	0.6	4.2	1.2	1.2	0.6	1.2	1.2	1.8	0.0	0.6	0
31	0	0	0	0	0	0	0	0.0	-0	2.4	1.8	0.0	0.6	0.6	0.6	0.6	0.6	0	0
30	0	0	0	0	0	-1	0.6	0.5	-1	0.0	0.6	0.6	2.4	0	1.2	1.2	3.6	1.8	0
29	0	0	0	0	0	0	3	0	-0	1.2	0.0	2.4	1.2	0.6	1.8	-0	2.4	1.2	0
28	0	0	0	0.6	-1	0	1.8	-0	1.2	0.6	1.8	1.2	0.5	-0	-0	1.1	3.6	2.4	-2
27	0	0	0	0	0	1.2	0	1.8	1.2	0	0	0.5	0.6	-1	0.6	0.6	4.8	2.9	0.6
26	0	0.6	0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.2	0.6	-0	0.6	0	2.4	0	0.6
25	0.6	0	0	1.2	1.8	0.6	0.6	1.7	0.6	-0	0	0.0	0.5	1.2	1.2	1.1	3	0	0
24	-1	0	0.6	1.2	0.6	0	0.6	0.6	0.6	-0	-0	0.7	0.0	1.7	0	0.6	5.4	0	0
23	0	1.1	1.7	0.6	1.8	0	0	1.8	0	0.5	1.2	-0	1.2	1.1	1.8	5.9	4.2	0	0
22	0	0	1.2	0.6	1.8	1.8	1.8	11	10	4.8	3.6	2.4	21	18	28	7.1	6.5	0	0
21	0	1.2	0	1.2	1.2	0.5	3	3	1.8	3	5.4	0.5	30	25	31	32	9.6	0	0
20	1.2	1.8	1.2	0.6	0.6	0.0	0.6	1.2	0	0.6	0.6	-4	7.7	12	25	22	3.5	0	0
19	0	2.9	1.2	0	0	1.2	-1	-0	-1	-0	-2	-4	8.6	24	32	25	0	0	0
18	0	0.6	0	0	0.6	-1	1.2	-1	-2	-2	-5	-4	16	16	18	2.3	-1	0	0
17	0	0.6	1.2	1.2	0	-2	-5	-5	-5	-6	-4	-4	8.3	11	10	1.8	0.6	0	0
16		0.6	0.6	1.1	-0	-1	-4	-4	-4	-3	-4	0	-3	0	-1	0	0	0	0
15		0	-1	0	-1	-4	-3	-2	-1	-1	-5	0	1.8	0	1.1	0	0	0	0
14			0	-5	-7	-4	-4	-1	-4	-5	-1	0	0	0.6	0	0	0	0	0
13					-4	-3	-1	-1	-4	-1	0	-1	0	0	0				
12					-5	-1	-1	-5	-3	0	0	-1	0	0					
11					0.0	-2	-1	-4	-1	0	0	-1	0.6	0.5	0				
10					-1	-2	-1	-2	-1	0	0	0	0	0	0				
9					-4	0	0.0	1.2	0.5	-1	0	0	0	0	0				
8					-3	-3	-2	-1	0	0	0	0	0	0.0	-1				
7					-3	-3	-1	-5	1.2	0	0	0	2.9	1.2	1.2				
6					-7	-7	-4	-1	0	0	0	0	0.6	0	0				



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DIFFERENCE IN PERCENTS OF 14 YEARS CELL FLOODED (> 4CM)

NOV 2, 1989

BASIC RAINDRIVEN (MUGO) MINUS BASE (BA90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0	0	0	0	0	0.6	-1	-0	-1	0.6	3	2.5	1.8	-1	0.6	1.1	4.1	4.7	[illegible]
33	0	0	0	0	0	0	-0	0.6	0.0	2.4	1.2	4.2	1.2	0.6	[illegible].6	1.2	2.5	1.3	10
32	0.6	0	-1	-1	0.0	0	0.6	0.0	1.2	5.3	1.8	3.6	1.3	0.5	-1	[illegible].2	3.6	1.8	[illegible]
31	0	0	0	-1	-1	-1	0.0	2.4	2.4	5.4	5.4	4.2	1.7	1.2	1.2	3.6	1.8	[illegible]	1.2
30	0	0	-1	0	-1	[illegible]	3	4.7	5.3	2.5	2.9	2.4	3	2.3	0.1	2.4	13	[illegible].3	3.5
29	0	0	0	0	0	1.2	[illegible]	4.9	5.3	5.9	5.9	5.4	2.4	-2	-2	[illegible]	10	6.6	[illegible]
28	0	0	0	0	-1	-1	[illegible]	4.9	6.5	4.8	5.4	2.4	-2	-4	-5	-0	6.6	11	[illegible]
27	0	0	0	-1	-1	0.6	[illegible]	4.8	5.4	4.7	2.4	2.3	-1	-5	-5	-0	2.4	[illegible]	8.4
26	0.6	0	0	-1	1.2	-1	[illegible]	5.2	4.7	2.4	3	0.5	-2	[illegible]	-1	0	-1	[illegible]	0.6
25	-1	0	-2	-2	-2	0	[illegible]	4.1	1.8	2.9	2.4	0.0	-6	[illegible]	-0	0	-1	[illegible]	0
24	-2	-1	-2	-1	[illegible]	0.6	[illegible]	0.0	-11	-10	-10	-8	-9	0	-40	-2	-5	[illegible]	0
23	-1	-4	-2	-2	1.8	[illegible]	[illegible]	-11	-13	-12	-9	[illegible]	[illegible]	2.4	1.2	5.9	-1	[illegible]	0
22	-2	-2	-1	0	-1	-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	21	38	41	45	0	0
21	-2	-4	-5	-4	-3	-16	-14	-2	-3	-2	2.5	[illegible]	29	26	35	39	31	1.8	0
20	-2	-4	-9	-7	-13	-18	-14	-7	-5	-3	-4	[illegible]	5.9	11	30	24	8.3	0	0
19	0	-4	-6	-2	-4	-5	-17	-13	-4	-4	-6	[illegible]	6.5	26	41	32	-1	0	0
18	0	-5	-0	-2	-4	-4	-5	-8	-4	-5	-8	[illegible]	13	18	29	-1	-2	0	0
17	0	-5	-4	-5	-4	-2	-12	-4	-9	-9	-5	[illegible]	17	12	15	0	[illegible]	0	0
16		-2	-5	-5	-2	0	-10	-10	-8	-8	-1	7.2	2.4	0.6	1.2	0	0	0	0
15		0	-1	0	-1	-7	-9	-7	-4	-4	3.5	4.8	4.7	2.4	-8	0	0	0	0
14			0	-2	-5	-7	-5	-6	-6	4.2	5.9	0	0	3.6	0	0	0	0	0
13					3	-6	-2	-4	-2	1.8	0.6	-1	1.2	1.2	0				
12					1.2	-2	-4	-5	3.6	0	0	1.2	0	0	[illegible]				
11					-1	-2	-3	-9	4.8	0	0	-1	0.6	0.5	0				
10					-1	-2	-2	-5	-1	0.6	0	0	0	-1	0				
9					-7	0	-0	3.6	0	0	0	0	-1	-1	1.8				
8					-4	-3	-4	0.6	0	0.6	0.6	0	-40	-5	-10				
7					-4	-5	-3	-6	0.6	0	0	0.6	1.8	-36	-2				
6					-3	-4	-0	-2	1.2	0	3.6	1.2	2.4	2.4	0.6				

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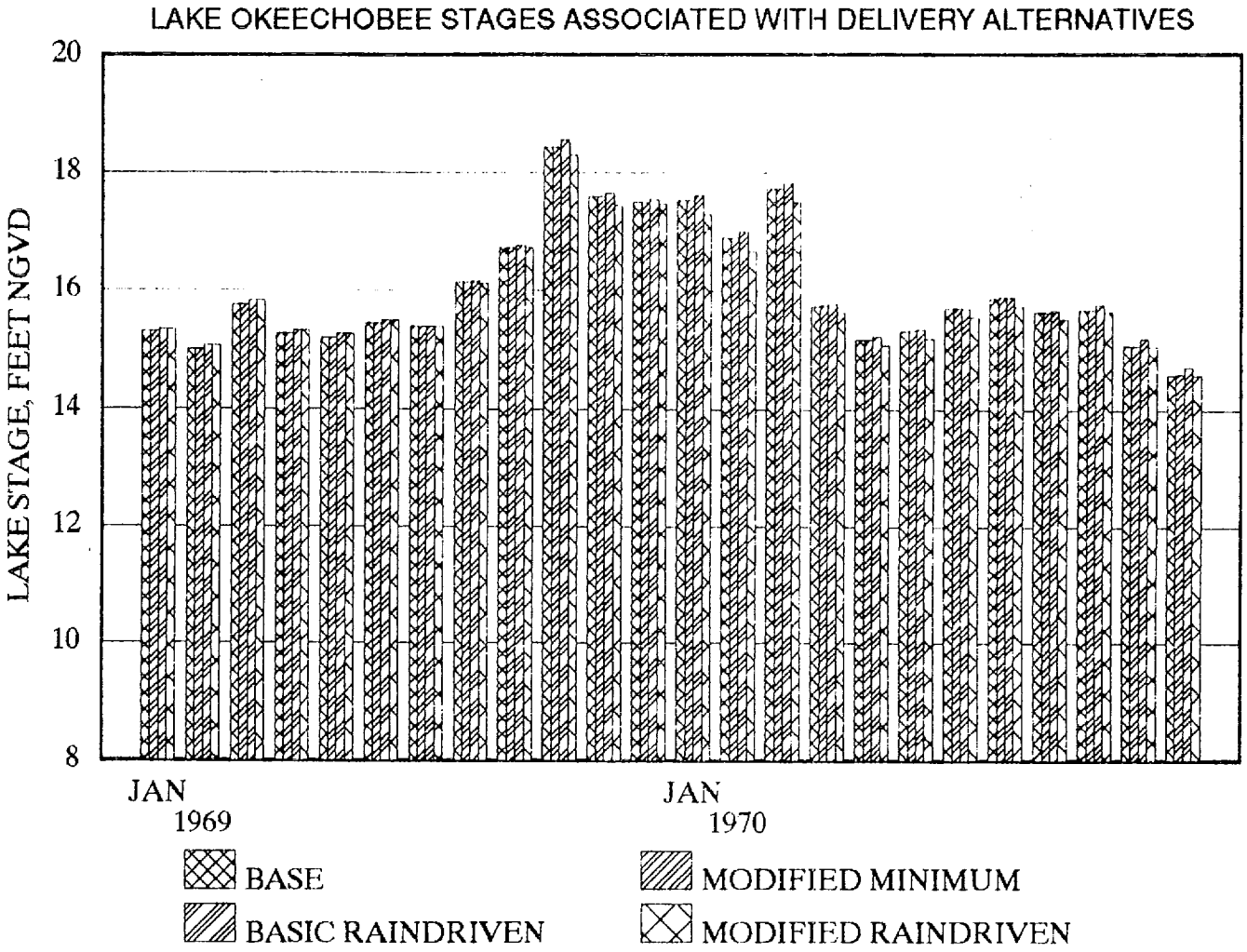
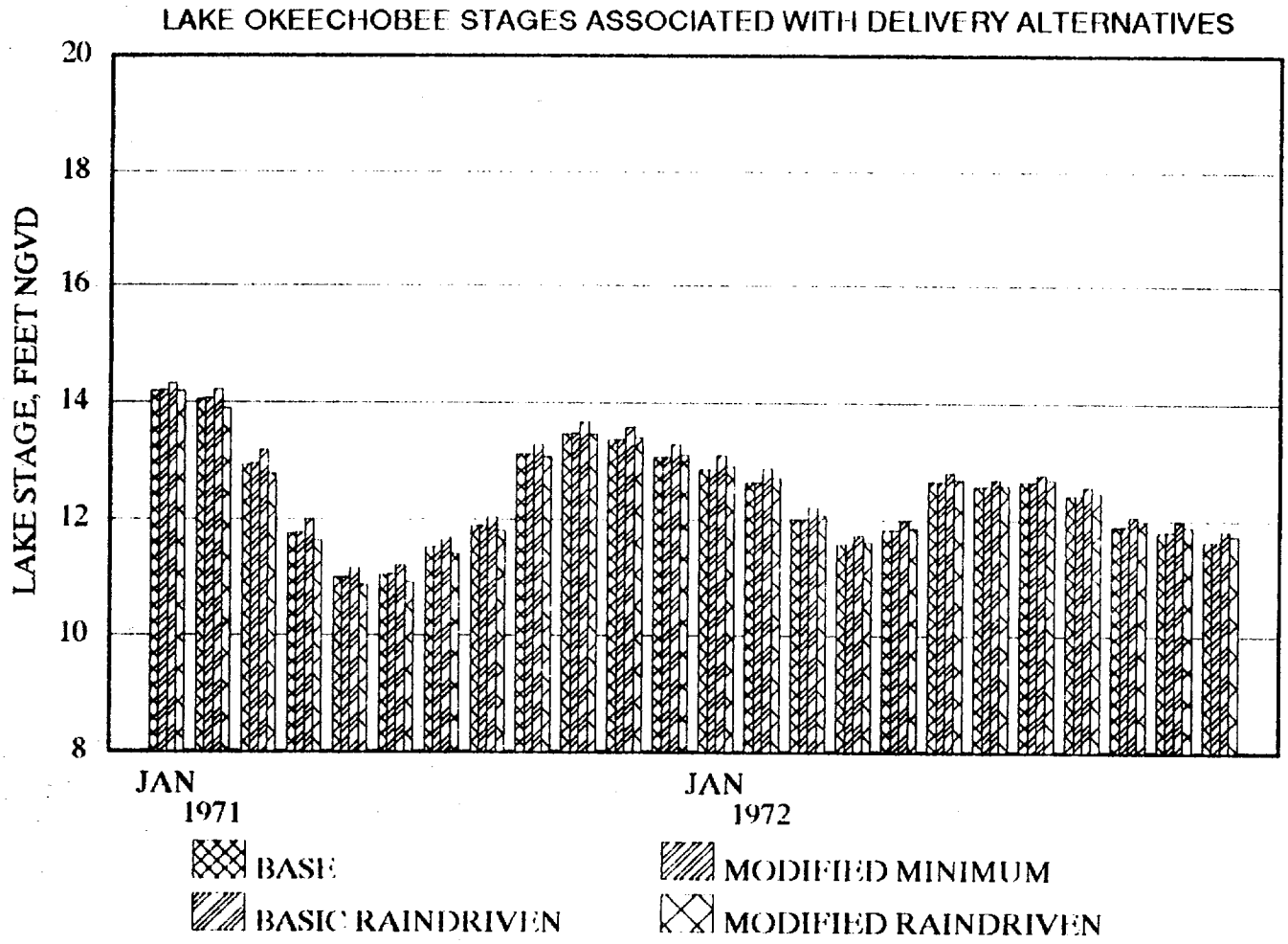
PROPORTION OF TIME FLOODED DEEPER THAN 4 CM; ACTION ALTERNATIVE MINUS BASE

MODIFIED RAINDRIVEN (MP90)

X COORD.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Y COORD.																			
34	0	0	0	-0	0.0	0.6	-[illegible]	-0	-1	0.6	5.4	4.8	6	5.[illegible]	4.2	7.1	5.9	2.9	1.2
33	0	0	0	0.0	-0	0.0	-0	1.2	-0	3	3.5	7.1	5.4	4.2	5.3	4.7	4.2	1.9	7.1
32	0.6	0	0	0	0	0.6	-0	0.6	0.6	5.4	2.4	7.1	4.8	6.6	4.2	[illegible].7	1.1	2.9	[illegible].6
31	0	0	0	0	-1	0.6	0.6	4.2	2.4	4.2	5.4	5.4	4.1	5.4	4.7	3.5	1.7	[illegible]	0
30	0	0.6	0.6	0	-1	2.4	[illegible]	2.3	2.4	2.4	4.1	5.4	4.8	3.5	3.1	2.4	[illegible]3	[illegible].3	0
29	0	0	0	0.6	-1	2.4	4.2	1.9	2.3	4.2	4.7	6.6	4.2	1.8	1.8	0.[illegible]	[illegible].4	7.1	1.2
28	0	0	0	0	0	0	3.6	1.8	2.9	3	5.4	4.2	1.7	0.6	-1	[illegible]	7.2	11	5.3
27	0.6	0	0.6	-1	1.8	3.6	2.4	3	3.6	5.9	3	3	3.1	0.0	-1	1.8	6	9.6	5.6
26	0.6	0.6	1.2	0	2.4	1.8	2.4	4.6	4.6	2.9	4.1	2.9	1.8	[illegible]	1.2	-0	2.3	4.6	0.6
25	0.6	-1	0	0.6	3.6	2.4	[illegible]	4.1	2.4	3	5.3	2.9	-1	1.6	1.2	-0	-0	0	0
24	-1	1.8	1.8	3	1.8	1.8	3.6	2.4	-0	-1	-1	-1	-1	2.4	-26	-1	-1	0	0
23	0.6	-1	2.3	2.4	4.2	3	1.8	1.2	-1	-2	-1	-1	2.3	3.5	1.2	7.7	3.6	0.6	0
22	-2	3.6	1.8	4.2	1.8	-10	-2	[illegible]	[illegible]	1.8	1.7	1.7	29	24	42	49	58	0	0
21	-1	0	-5	-2	0.6	-16	-11	-2	-3	-1	4.2	-2	30	28	39	44	35	1.8	-1
20	1	1.8	-6	-2	-11	-16	-12	-6	-4	-2	-1	-4	7.8	12	32	24	16	0	0
19	0	-1	-2	-1	-3	-2	-16	-12	-4	-4	-4	-2	7.7	29	45	34	-2	0	0
18	0	-3	0.0	0.6	-2	-1	2.4	-7	-3	-4	-5	-8	18	18	29	-6	2	0	0
17	0	-4	-2	-3	-1	1.7	-11	-1	-5	-7	-5	-4	21	18	16	-2	0	0	0
16		1.8	-4	-2	0	6.5	-8	-5	-6	-5	3.5	14	4.8	0.6	1.2	-1	0	0	0
15		0	2.4	0.6	1.7	-4	-6	-6	-2	-2	11	5.4	9.5	2.4	-11	0	0	0	0
14			0	1.2	-1	-5	-5	-4	-5	4.8	11	0	0	2.4	0	0	0	0	0
13					7.2	-4	-2	-3	0.6	5.4	1.2	2.3	3	0.6	0				
12					6	-2	-2	-3	8.4	0.6	0	0	-0	0.6					
11					0	-1	-2	-3	7.2	0	1.2	-1	0.6	0.5	0				
10					-1	-2	-1	-3	1.8	-1	0	0	0	-1	0				
9					-5	0	0.0	6.6	0	1.2	0	0	-1	-1	0				
8					-3	-3	-4	-1	0	0.6	0	0	-49	-4	-10				
7					-2	-4	-1	-2	0	0	0	0.6	2.9	-36	-2				
6					-1	-2	-4	-1	0.6	0	1.8	1.2	2.4	2.4	0.6				


LAKE OKEECHOBEE STAGES ASSOCIATED WITH DELIVERY ALTERNATIVES
LAKE STAGE, FEET NGVD
20
18
16
14
12
10
8
JAN
1969
JAN
1970
BASE
MODIFIED MINIMUM
BASIC RAINDRIVEN
MODIFIED RAINDRIVEN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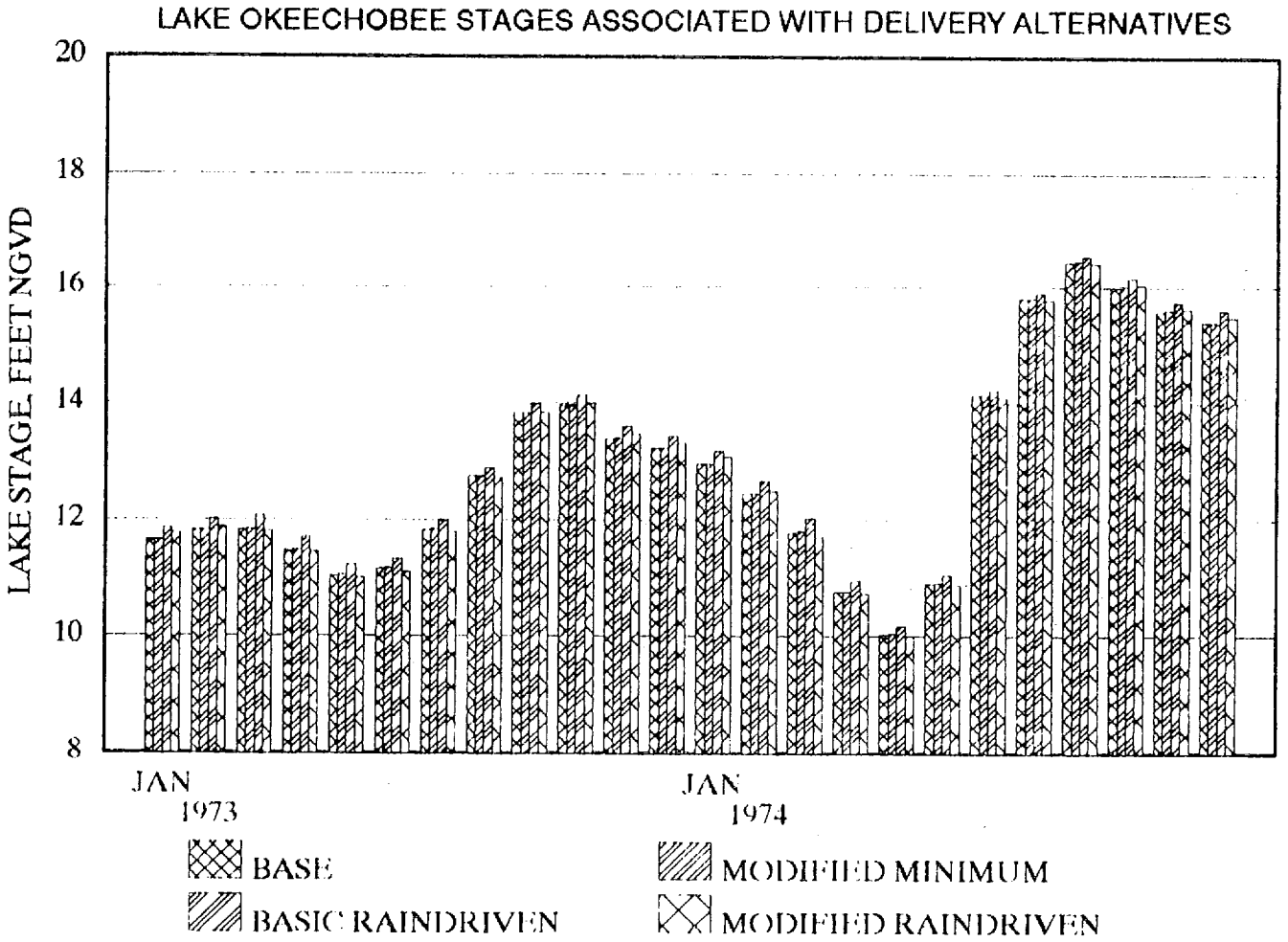
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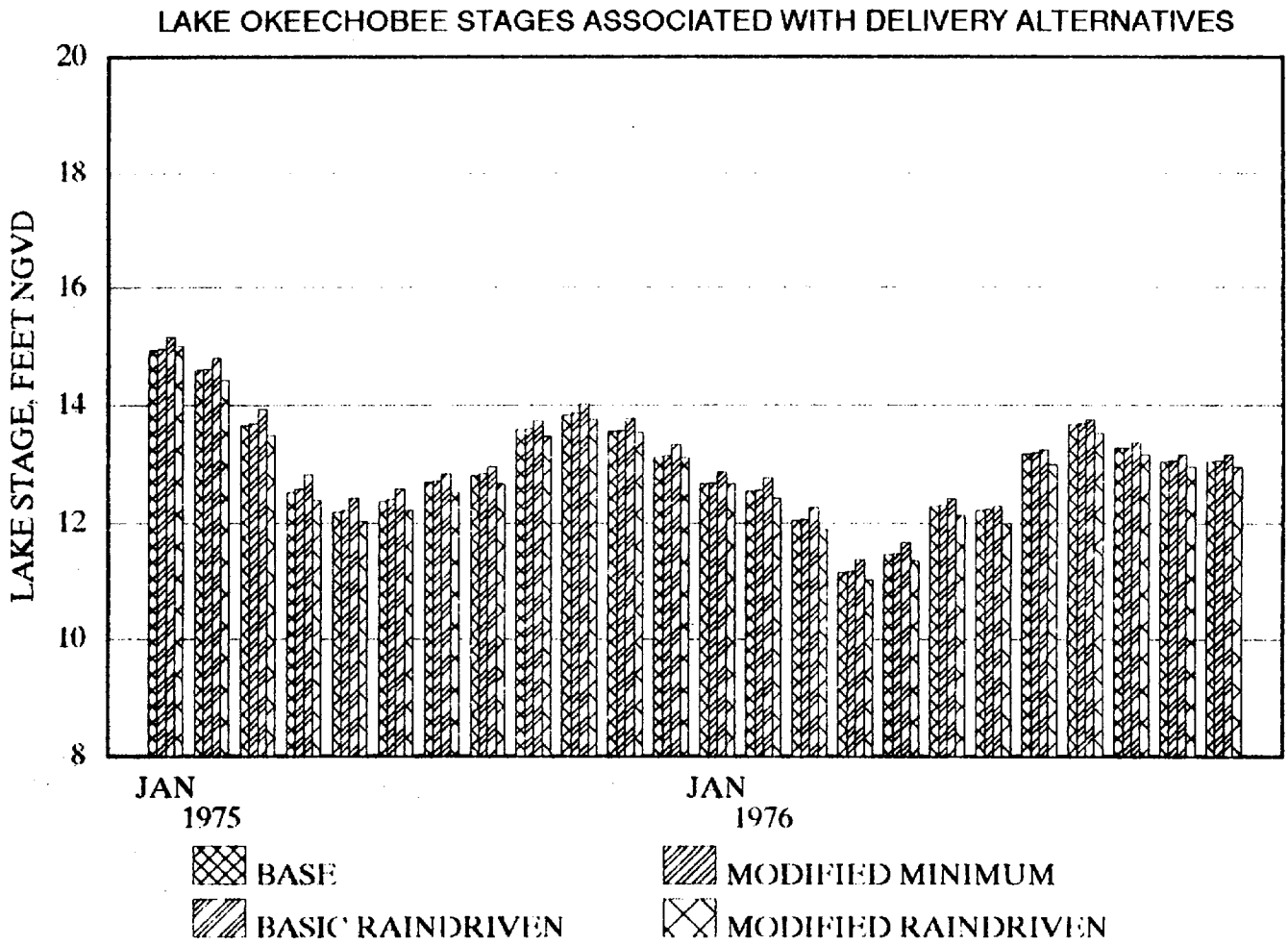
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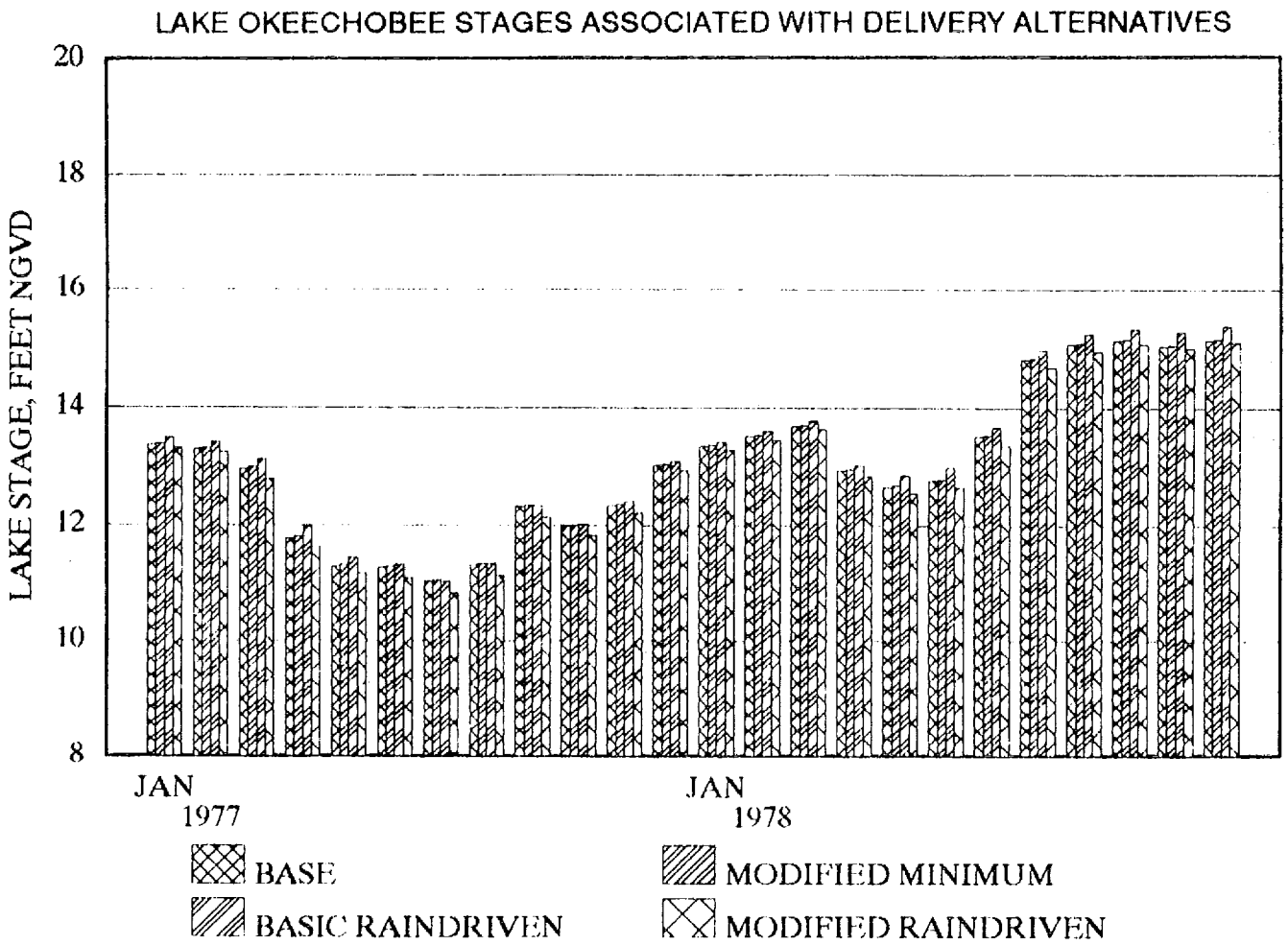
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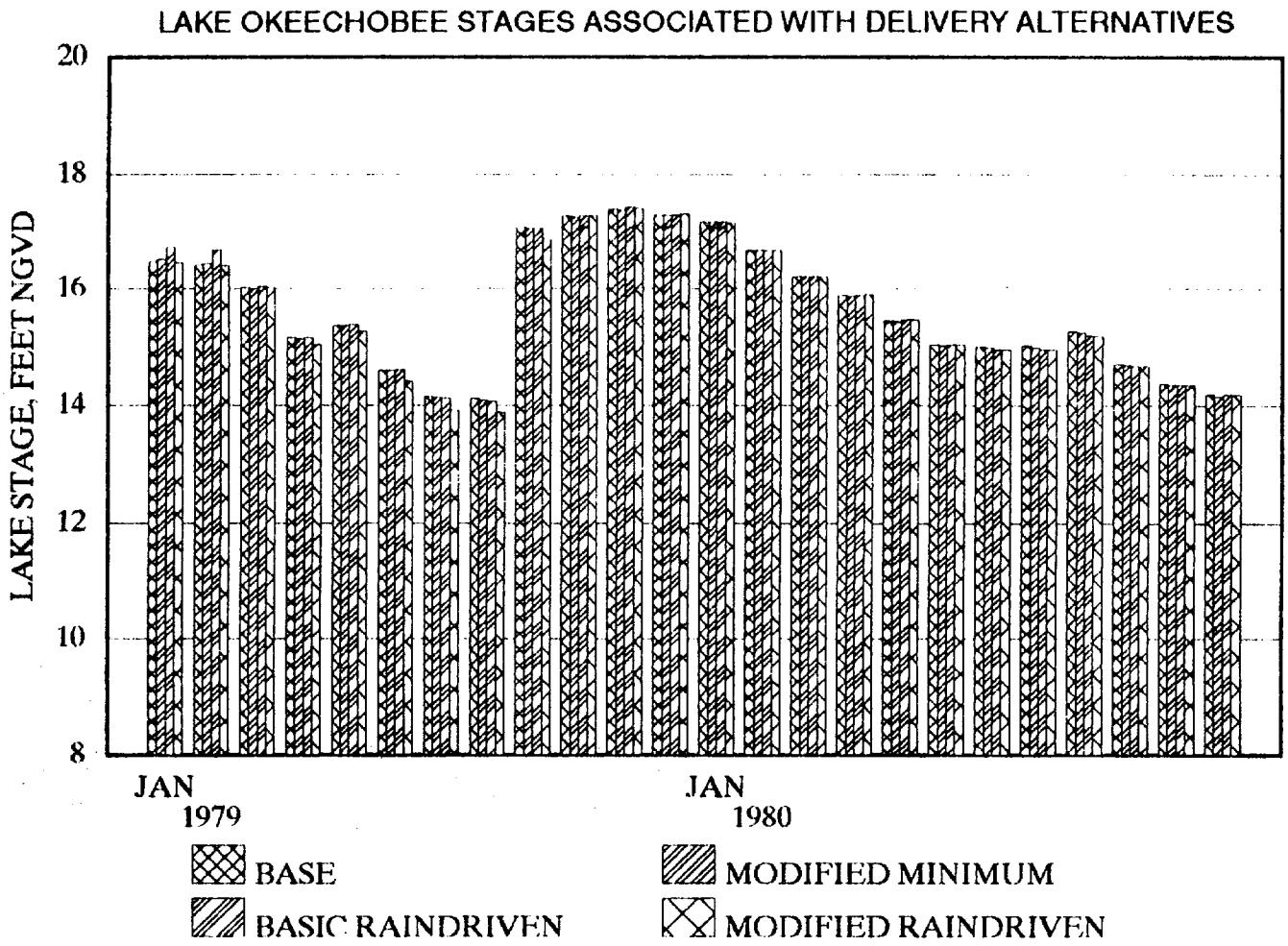
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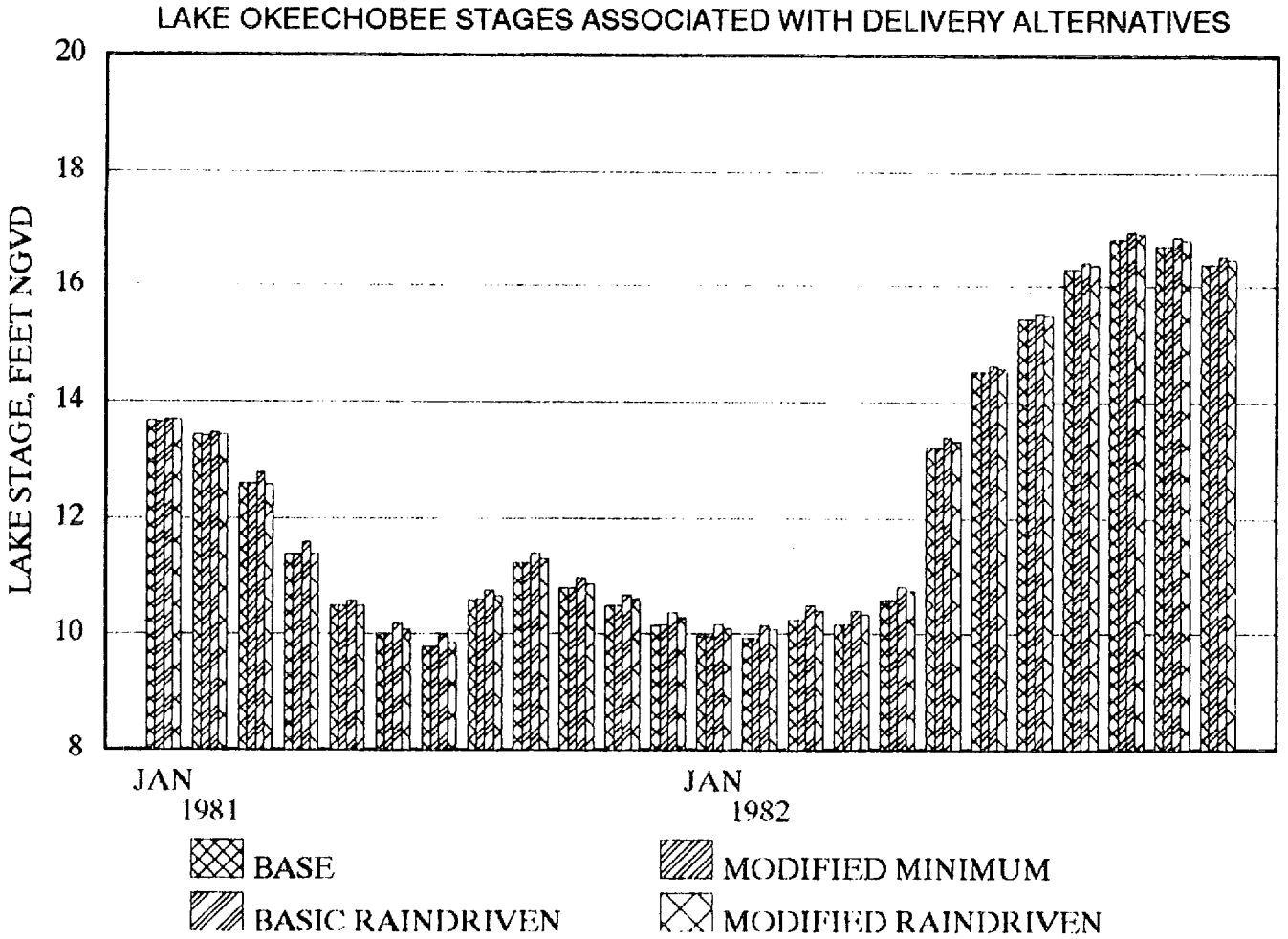
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FWCA REPORT

APPENDIX G

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

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FLORIDA GAME AND FRESH WATER FISH COMMISSION

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110 43rd Avenue, S. W.
Vero Beach, Florida 32968
December 19, 1989

Dr. Arnold Banner
United States Department of Interior
Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961

Re: Modified water delivery to Everglades National Park

Dear Dr. Banner:

I have looked over the data you supplied me on the four alternatives currently under consideration for water delivery to Everglades National Park. The following comments are based on my initial interpretation of these data, and do not comprise an official agency position. As you know, Jim Rodgers has been in the field these last few weeks doing the annual kite survey, so I have not had an opportunity to discuss this with him.

Since the primary objective for modifying water deliveries to the Park is to increase the hydroperiod in Northeast Shark River Slough (NESRS), the most striking thing about your data was the lack of significant difference in the three "action" alternatives, as far as NESRS is concerned. For this objective, then, the three "action" alternatives should be considered equal.

Other areas of no significant difference among any of the alternatives are the impacts on Lake Okeechobee water levels and Conservation Area 3B hydroperiod. The latter is interesting, since the rain driven alternatives deliver water to NESRS via sheetflow across 3B. This suggests to me that Area 3B is a rather inefficient conduit for water delivery, perhaps because of its documented "leaky" nature. Area 3B currently has excellent everglades wildlife values and good water quality. It seems ill-advised from both a water quality and quantity standpoint to take poorer quality water from the L-67 canal and place it in the cleaner, but "leaky" everglades of Area 3B. I would recommend an option which avoids 3B altogether.

The future of South Florida water use will be increasing demand. Normal rainfall will no longer maintain normal surface and ground water levels. This will increase the importance of drought refugia, either natural or man-created,

as we enter the next century. The slough in the southeast corner of Conservation Area 3A is already a critical habitat for snail kites, wading birds, and everglades fisheries during droughts, and I believe we would be wise to maintain this slough habitat.

Looking over the three "action" alternatives, I lean toward the modified minimum, with the addition of Structure 333 to enhance delivery to NESRS. It would not involve delivery through Area 3B, it maintains the drought refugia in Area 3A, it is better for wood storks based on the habitat model, it requires less fill, and it costs less than the other "action" alternatives.

Sincerely,

Brian Barnett

Brian S. Barnett
South Florida Section Leader

BSB/rs
ENV 2-1-1/5
cc: Bradley J. Hartman
R. Daniel Dunford

Yale University New Haven, Connecticut 06511

DEC 19 1989

SCHOOL OF FORESTRY AND
ENVIRONMENTAL STUDIES

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Dr. Arnold Banner
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961

18 December 1989

Dear Arnold,

Thank you for the opportunity to comment on the model runs and alternatives related to modified water deliveries to Everglades National Park. I especially appreciate the careful way in which you have presented the information from model runs and given several types of data to connect model outputs with other types of information or simulations.

The Snail Kite population in Florida is most strongly affected when the Everglades dryout (Fig. 1). Kites disperse out of the large Everglades wetlands accross the Florida peninsula in search of food, trying to survive in small isolated wetland habitats (Beissinger and Takekawa, Florida Field Naturalist 11:89-106; Takekawa and Beissinger, Conservation Biology 3:302-311). During these events, the population crashes. The interval between drydowns in the Everglades then becomes critical to allow the kite population to rebound to previous levels.

Conservation Area 3A (CA3A) is probably the most important part of the Snail Kite's critical habitat. Proposed changes in water management will have strong affects on water levels in CA3A and habitat suitability for the kite. I believe that your modelling approach shows clearly how both the spatial and temporal variation in water levels will be affected by the various alternatives.

The Basic Raindriven model will have the greatest impact on the kite population. Hydroperiods in CA3A would be severly reduced. Hydroperiods created in Everglades National Park (ENP) and CA3B would still not become long enough to support Snail Kites. Judging from the data presented for the frequency of drying at guage 3-28, which is strongly related to kite population numbers (Fig. 1), the Basic Raindriven model would increase the likelihood of kites dispersing from the Everglades approximately six-fold.

I modelled the effects of the temporal occurrence of drought or dispersal events on kite population viability (Fig. 2, 3, and 4). Kite populations are not likely to cycle stablely, that is be viable, unless dryouts occur at a 3.67 to 4.0 year interval. Such an interval was achieved during the past decade in CA3A, e.g., Base conditions. The Basic Raindriven model will result in six dispersal events in 14 years (causing dispersal every 2.33 years) and is highly likely to result in the downward cycling of kite numbers towards extinction. No long hydroperiod habitat (some flooding in all years) would remain. Such habitat may be important for supporting both kites and snails during drying events. In my opinion, implementation of such a plan would result in CA3A becoming unsuitable for kites. Finally, the results of the

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Wood Stork habitat suitability model do not suggest that this alternative would enhance stork populations.

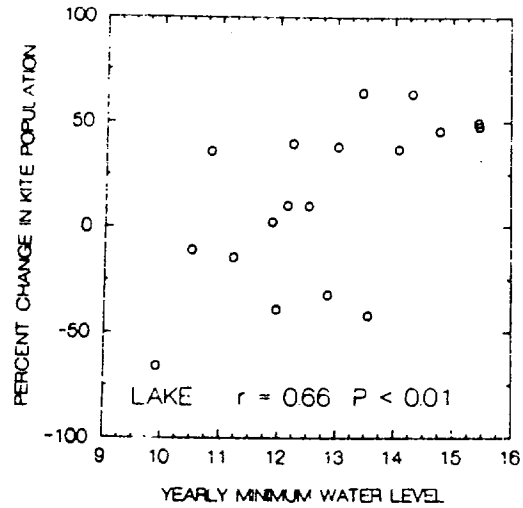
The Modified Raindriven Model offers a slight improvement on the frequency of kite dispersal events, compared to the Basic Raindriven alternative, but still would provide no long hydroperiod areas in CA3A. Bringing water into CA3A at 9 fmsl should help decrease kite dispersal events and may be necessary if any type of structural modification associated with the Basic Raindriven Alternative is undertaken. This plan would have no apparent negative affect on water levels or the kite population on Lake Okeechobee as a result of shifting water to CA3A.

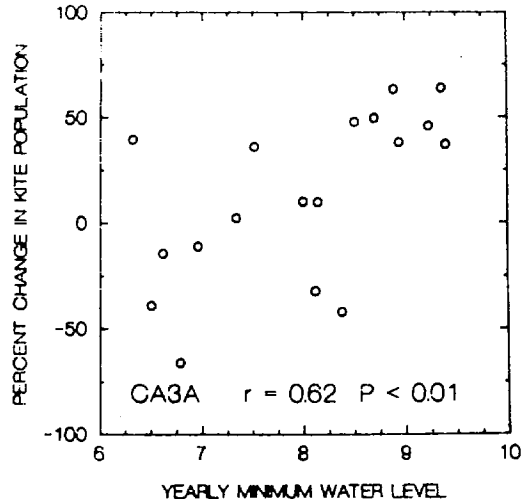
For Snail Kites, the Modified Minimum provides the least change from Base conditions. Under Base conditions the kite population has managed to cycle in a stable manner, recovering from massive mortality caused by dry-outs. If the Modified Minimum alternative would allow for adequate habitat enhancement in ENP, it could be undertaken as an interim change that would allow time for further field testing of kite population viability models and GIS-based models developed by ENP and USFWS.

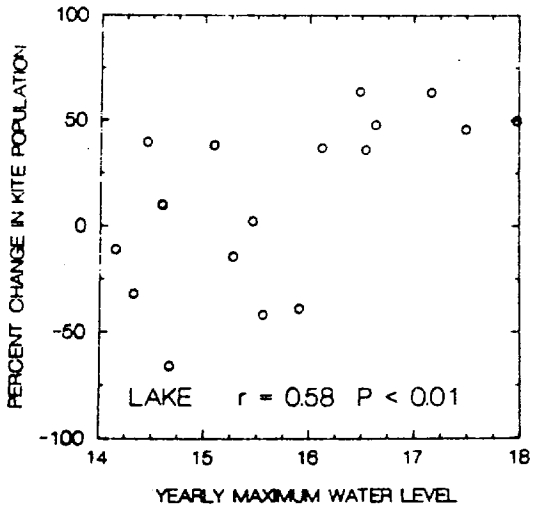
Sincerely,

Steven R. Beissinger
Assistant Professor of Wildlife Ecology

Figure [illegible] Change in Kite Population in Florida in relation to water levels.







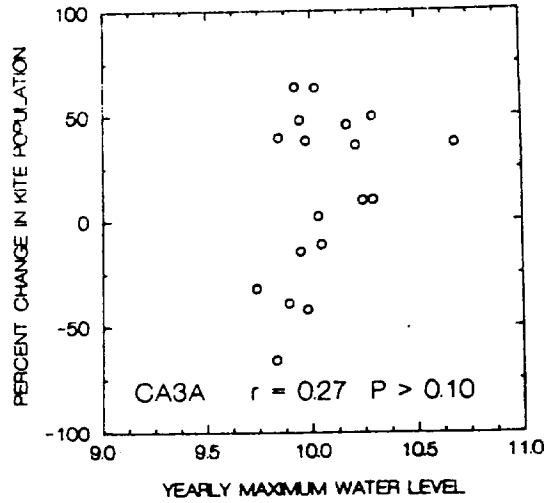


FIG. 2. Kite Population Simulation in relation to interval between logging events.

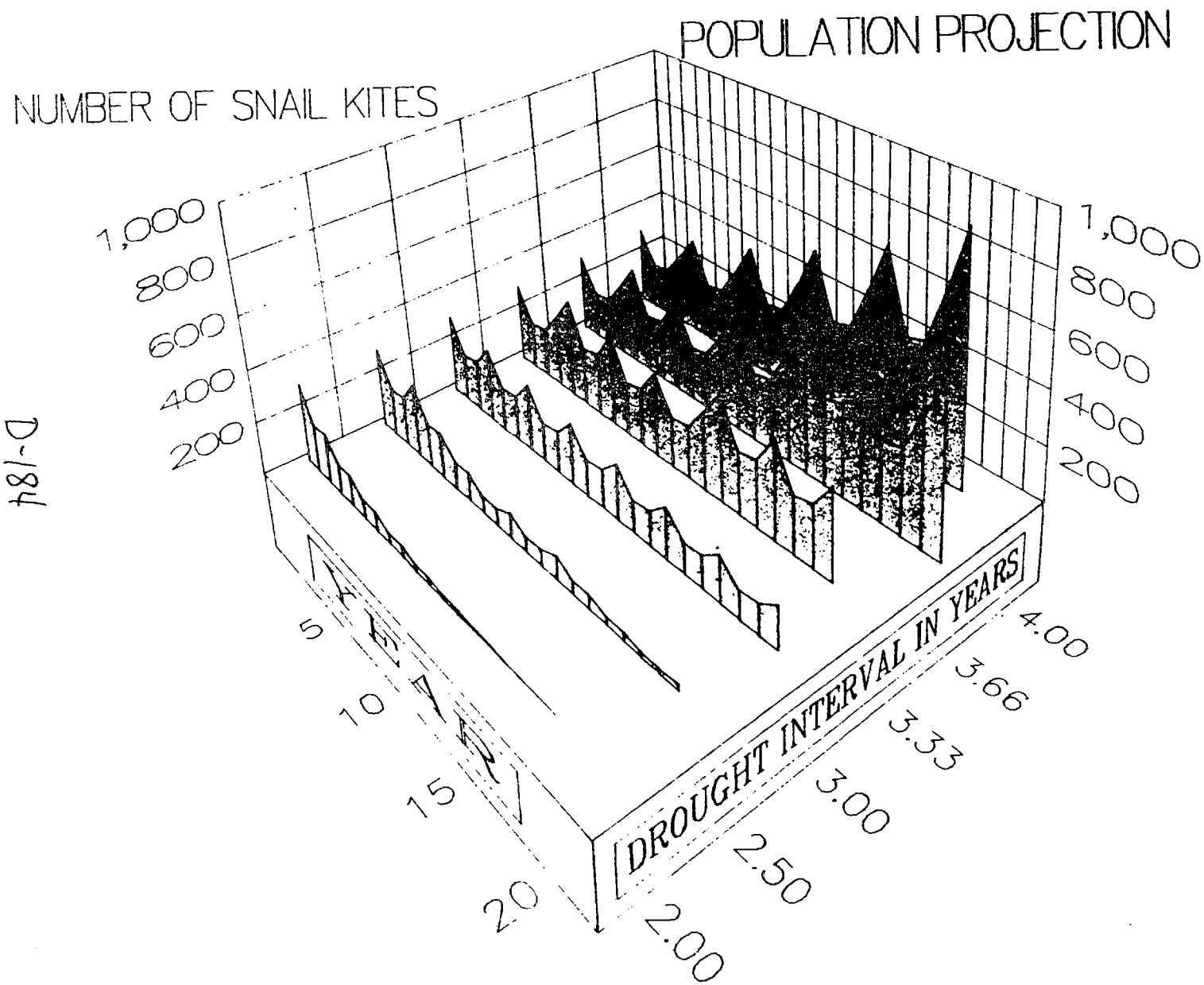


Fig. 3.

STOCHASTIC DEMOGRAPHIC SIMULATION OVER 50 YEARS AND SENSITIVITY ANALYSIS (N = 300 RUNS)

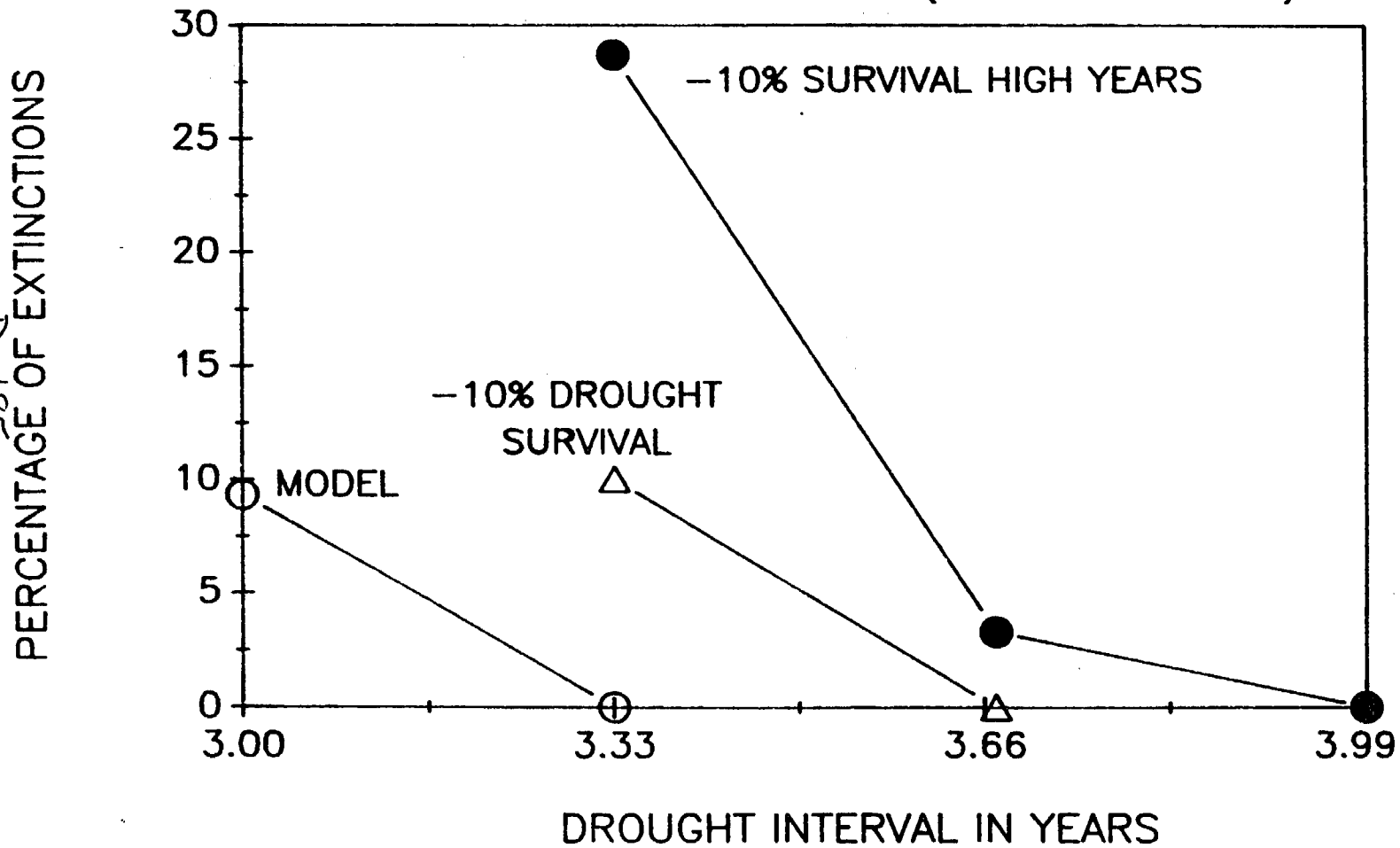
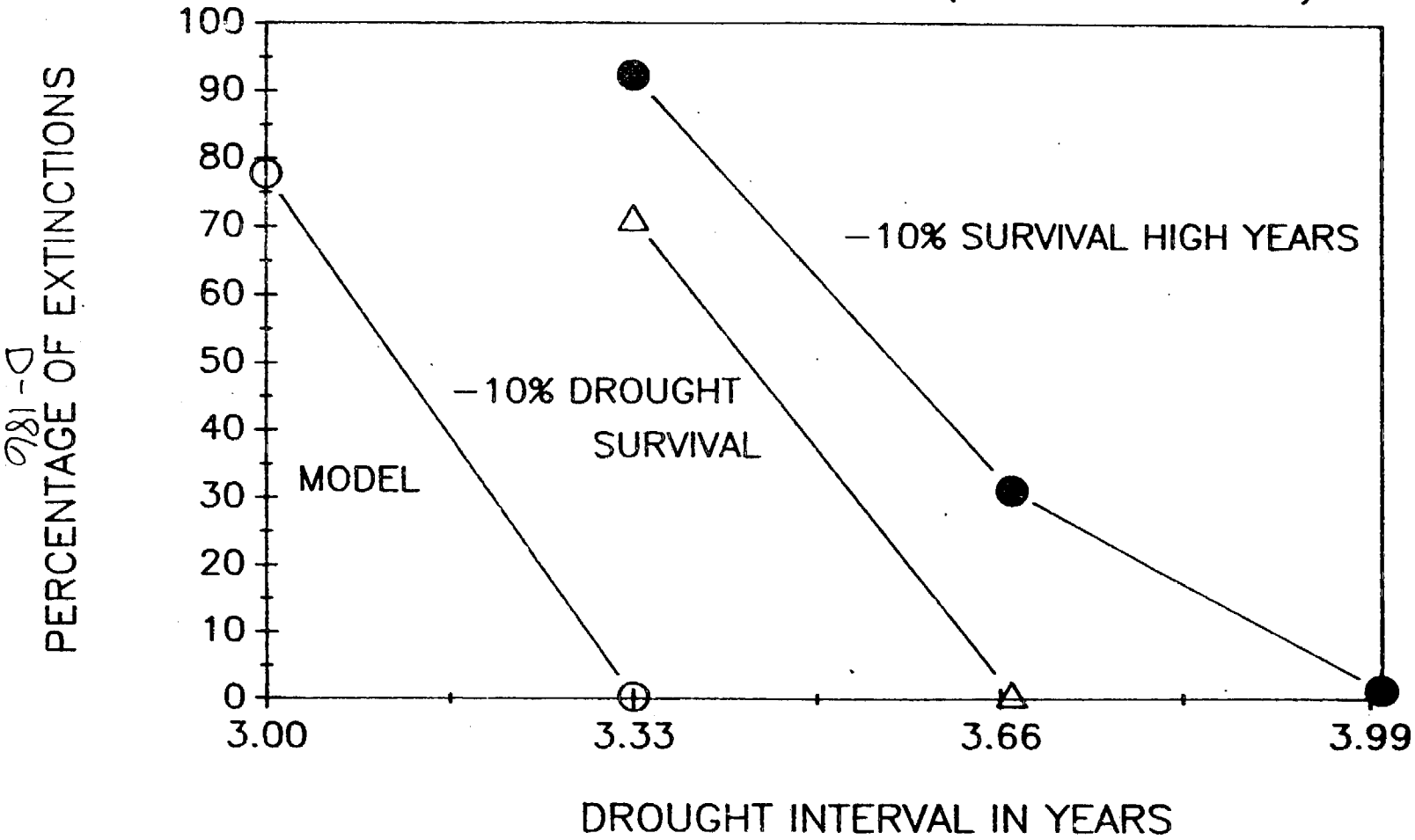


FIG. 4.

STOCHASTIC DEMOGRAPHIC SIMULATION OVER 100 YEARS AND SENSITIVITY ANALYSIS (N = 300 RUNS)



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JAN 11 1990

United States Department of the Interior
NATIONAL PARK SERVICE
EVERGLADES NATIONAL PARK
AND
FORT JEFFERSON NATIONAL MONUMENT
P.O. BOX 279
HOMESTEAD, FLORIDA 33030

IN REPLY REFER TO:

N22

January 9, 1990

Mr. Arnold Banner
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, Florida 32961-2676

Dear Arnold:

This letter includes an assessment prepared by the South Florida Research Center of the impacts that four water delivery programs proposed for Everglades National Park (ENP) may have on snail kite "critical habitat" in Water Conservation Area 3A (WCA-3A). The narrow focus of this current analysis is prompted by preliminary findings (as of 22 Dec 1989) from the Fish and Wildlife Service (FWS) that one of the proposed delivery options (MU:Rainfall) will require a "jeopardy" opinion, in that it would result in degradation of WCA-3A as critical habitat for kites. The threat of a jeopardy opinion has substantially delayed the development of a General Design Memorandum by the Corps of Engineers, for the structural changes in the water delivery system that have been requested by the National Park Service. Our assessment of impacts on snail kites differs from that prepared by the FWS. Would you review the following assessment prepared by the Research Center, as well as the statements of the Park's restoration philosophy and goals, that are summarized in this letter? Any comments or criticisms you may have will help us resolve the differences, and misconceptions, that currently are hindering the Everglades restoration process. As always, we would appreciate an early reply. We are facing deadlines, unfortunately, for preparing our final review of the four water delivery proposals.

A most important point to make during this evaluation process is that the National Park Service has not agreed to support or recommend a specific water delivery plan. We strongly doubt that any of the four delivery options being reviewed at this time include sufficient volumes of water to meet the restoration goal.
Our only objective at this point is to see the water delivery system redesigned to provide greater flexibility for future deliveries, in terms of timing, distribution, and volume of water. The long-term goal is to reschedule water deliveries in the central and southern Everglades so that historical patterns of timing, distribution, and volume are reestablished in order to increase the area and magnitude of biologically viable wetlands throughout the system. We would argue, in fact, that it is premature to be attempting to assess the impacts that any water delivery plan will have on wildlife until we decide the

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questions of added volumes of water, and until we are prepared to recommend a specific delivery schedule. This latter step will only occur following a lengthy period of experimental water deliveries with the structural changes in place, coupled with refined hydrological modelling for the region. During this process, we will be seeking your council and support as we assess wildlife responses.

Our current "preference" for the Rainfall (MU) option is for two reasons only: 1) Of the four options evaluated by the FWS, the Rainfall is the one that best assures the structural changes that we seek; and 2) Conceptually, it is a stronger step in the direction of ecosystem restoration than are the other three. Conversely, we are opposed to the Modified Rainfall (MP) option because it represents a management philosophy that we are convinced will greatly hinder the program for ecosystem restoration, by setting a single-species management priority for a large region of the former Everglades. On a more practical basis, this option is more likely to result in detremental surges of high water through the S-12 structures into northern ENP, during the alligator nesting season. The Base (BA) and Modified Minimum (BC) options do not include structural changes necessary for flexible water delivery into the Northeast Shark Slough region.

Everglades National Park believes that a lengthy process of experimental water deliveries, coupled with close monitoring of an array of indicator and endangered species, is the best approach for developing a proper water delivery plan for the central and southern Everglades. We are committed to maintaining the Snail Kite, and a wide range of other characteristic Everglades species in this region. We oppose the concept of "critical habitat" where it forces management options that are too rigid for ecosystem restoration, and where one endangered species receives benefits at the probable or certain detriment of other endangered species. We wish to insure that a viable kite population survives in this region, although we seek the flexibility to allow that population to adjust geographically to the conditions of a more natural ecosystem. We know, in a strong quantitative fashion, the habitat requirements for SnailKites, Cape Sable Sparrows, alligators, Wood Storks, and other waders, etc., thanks to a plethora of superior studies conducted on these species by a host of Everglades biologists: Bancroft, Bass, Beissinger, Bennetts, Dalrymple, Fleming, Frederick, Kushlan, Ogden, Robertson, Snyder, Sykes, Werner, etc. As a result, we know what will be required to keep these species in the system!

The assessment of the four proposed water delivery options conducted by the FWS was largely derived from a hydrological model developed by the Corps, which predicts the hydrological events that are likely to occur under each of the four proposed delivery schedules. We used the same Corps hydrological model. Differences in our conclusions appear to be due to the different ways that we treated output from the model. The FWS (letter date 9 Nov 1989) used several variables as criteria for comparing hydrological conditions, including the percentage of cells (cell = 4 sq miles) flooded 6<>14 years, the number of years when gauge 3-28 went dry, and a measure of cumulative flooding ("average percent of flooding to 5 cm deep or more").

We do not see the biological basis, in terms of what is known of kite habitat requirements, for the 6<>14 year range, or the minimum 5 cm criteria. We also suggest that a more accurate assessment of the quantity of kite habitat can be developed by looking at water depth in every cell in the WCA-3A critical habitat region (about 120 cells), rather than at a single gauge. The hydrological feature that is considered to have the greatest negative impact on kite habitat is drought; this feature is assessed by looking at the areal extent of drying and the frequency of dry-outs in the WCA-3A zone of critical habitat (south of Alligator Alley). Our assumptions are as follows: Water

management practices that reduce the extent and frequency of dry-outs favor kites. A simple, accurate measure of whether hydrological conditions are favorable for kites can be obtained by looking at April hydropatterns, when surface water levels are most often at the lowest annual levels. A year with a dry-out in April would be assumed to result in dispersal of the WCA-3A kite population and would be considered a negative year for kites, while a year without an April dry-out would most likely maintain favorable habitat conditions for kites in WCA-3A throughout the dry season. Finally, we assumed that actual hydrological conditions in WCA-3A during the 14-year period analyzed by the model (1969-1982) were good for kites (population more than doubled in WCA-3A), and that any water management program that matches or improves upon the pattern of dry-outs (equals or reduces their extent/frequency) will be favorable to kites. Thus, we compared the hydrological model's predicted hydropatterns, by cell, for the end of April each year, for the years 1969-1982.

We defined a dry-out as a year (end of April) when water levels dropped to less than 0.5 feet of surface water in 95 percent (or greater) of the cells in WCA-3A. The choice of a minimum 5 percent area as a drought refugia for kites in WCA-3A is based on the report in Takekawa and Beissinger (1989) of a 32 km^2 wetland in Palm Beach County successfully functioning as a drought refuge for over 350 kites. Five percent of WCA-3A is six cells, or about 61 km^2, about twice the area of the reported example. The choice of a minimum 0.5 feet of water as a criterion for functional kite feeding habitat is conservatively based on the 10 cm depth suggested by Bennetts, Collopy, and Rodgers (1989, ms) as the minimum depth required to maintain suitable feeding habitat.

Of the four alternative water delivery options, the Base option represents the "no action alternative", whereby the system would be operated as it was with the minimum delivery schedule and the current structures, between 1970 and 1982. The model for the Base hydropatterns, as well as for the other three alternatives, includes assumptions regarding 1990 water demands that appear to be much too severe. In reality, all four model runs should show generally wetter conditions, if they could be adjusted to "real world" conditions. The Base delivery program was actually a period when the Snail Kite population remained relatively stable in WCA-3A during the years 1969-1977, and approximately doubled in size between 1978 and 1982 (Bennetts, et al. ms).

In view of the inaccuracies in the hydrological model regarding actual water depths (Corps estimates accuracy at ±0.5 feet); and 1990 water demand assumptions, the much more useful evaluation of the four model runs is to compare relative values among the alternatives, rather than to accept the numerical values shown. This comparative analysis shows that the three newly proposed delivery schedules (modified minimum, rainfall, modified rainfall) will produce similar or improved habitat conditions in WCA-3A, when matched against the Base plan (Tables 1, 2).

We see no grounds for a jeopardy opinion for any of the three water delivery alternatives. Table 1 suggests that the Base and Modified Minimum plans will provide a pool of water large enough and deep enough to serve as good foraging habitat for kites with about equal frequency; that the Rainfall plan is a modest improvement, and that the modified Rainfall is a large improvement compared to Base. Table 2 shows dry-out frequencies ranging between 4.3 and 13.0 years. Bennetts and Collopy (1988) suggest that ideal kite nesting habitat in the Everglades marshes should have dry-outs at a frequency ranging between 1.7 and 4.0 years. Unfortunately, the dry-out frequency suggested by Bennetts et al. can not be directly compared to the values shown in Table 2. The latter do not represent "real world" conditions because they are influenced by 1990 assumptions on water demands. Actual conditions in WCA-3A will be wetter than is shown in Table 2, until the time when water demands on the total system reach the level predicted by the

1990 assumptions. When (if) this time comes, one could argue that the long-term survival of endangered species in the Everglades region might best be guaranteed if populations are established or maintained in ENP and/or Loxahatchee NWR, where federal law may be most effective for protecting these populations. The Modified Rainfall plan, the only one of the four to require additional water from Lake Okeechobee, also appears to be more of an improvement over Base conditions than are the Modified Minimum or Rainfall alternatives. Most of the add-on water called for in the Modified Rainfall would be delivered into WCA-3A, in order to "improve" this area for kites (=strengthen the impoundment conditions in WCA-3A over the current condition). In fact, our analysis shows that the Modified Minimum and Rainfall alternatives generally maintain WCA-3A kite habitat, and that the Modified Rainfall provides more water into WCA-3A than is needed in order to maintain a healthy kite population. We suggest that while it is undoubtedly true that more water needs to be delivered into the southern Everglades, that the real need and justification for additional water is regional restoration of the ecosystem, and repair of seriously degraded wetlands in and adjacent to Everglades National Park.

Sincerely,

John

John C. Ogden
Acting Wildlife Program Manager

Table 1. Percent of WCA-3A critical habitat covered by > 0.5 feet of surface water during late April, 1970-1982, for each of four alternative water delivery options.

YEAR	BASE	MOD. MIN.	RAINFALL	MOD. RAINFALL
1970	95.12	91.05	97.56	99.19
1971	5.69	1.65*	0.0*	5.69
1972	41.46	63.41	69.91	68.30
1973	0.0*	0.0*	4.88*	6.50
1974	4.88*	0.81*	0.0*	6.50
1975	12.19	7.32	1.63*	11.38
1976	0.81*	4.88*	6.50	17.08
1977	0.81*	2.44*	5.69	17.08
1978	26.83	43.09	59.34	61.79
1979	59.35	69.10	66.67	68.29
1980	76.42	78.05	77.24	82.92
1981	0.0*	3.25*	0.81*	19.52
1982	1.63*	6.50	9.75	7.32
*No. years with dry-outs (<5.0%)	6	6	5	0

Table 2. Percent of cells in WCA-3A critical habitat with annual 12-month hydroperiod (all depth classes).

YEAR	BASE	MOD. MIN.	RAINFALL	MOD. RAINFALL
1970	94.31	95.12	94.31	94.31
1971	13.82	14.63	7.32	30.89
1972	16.26	18.70	7.32	15.45
1973	6.50	15.45	26.02	24.96
1974	3.25*	3.25*	0.0*	0.0*
1975	16.26	8.94	0.0*	7.32
1976	15.45	24.39	23.58	41.46
1977	22.76	26.83	31.71	42.28
1978	31.71	41.46	44.72	54.47
1979	43.09	61.79	70.73	73.98
1980	73.17	78.86	78.05	78.86
1981	4.88*	26.83	26.02	47.97
1982	6.50	13.01	1.63*	12.20
*No. years with dry-outs (<5.0%)	2	1	3	1
Frequency of dry-outs	6.5	13.0	4.3	13.0

United States Department of the Interior
FISH AND WILDLIFE SERVICE
P.O. BOX 2676
VERO BEACH, FLORIDA 32961-2676

January 18, 1990

Mr. John C. Ogden
Everglades National Park
P.O. Box 279
Homestead, Florida 33030

Dear John:

This is in response to your letter of January 9, 1990. By now, you should have had a chance to review our Biological Opinion on the water delivery alternatives, and so the information which I relied on and conclusions formed need not be repeated here.

At your request, I reviewed your own assessment of the alternatives regarding the snail kite. I disagree with the way in which you used the available hydrologic data and with your selection of a threshold for drought conditions. First, the end of April was not the dryest period during 9 of the 14 years under the Basic Raindriven Plan. May was dryest more frequently, and the complete drying of WCA-3A occurred only in May (see enclosed table). This biased your results.

The selection of 5 percent of the cells as a threshold seems to have no basis with respect to availability of drought habitat. Most drought refugia are smaller than even one cell, while the Palm Beach Catchment Area (not a drought refuge, but probably an adjacent foraging area) was equivalent to about 3 cells or less. If 3 cells had been taken as the "threshold", the results would have been very different; both Base and Modified Minimum would have looked far better. In my analysis, I avoided the imposition of such a threshold.

With regard to the philosophy behind your arguments, I agree that a comprehensive restoration would be most desirable if feasible. Where partial restoration is all that can be carried out, one should be careful not to eliminate even artificial remnants of Everglades habitat types, if they will not be replaced.

I agree that sufficient water volumes could restore the original longer hydroperiod wetlands, but such water volumes are not predicted by the project planners (Corps). Therefore, we've identified potential effects on the kite and wood stork under the predicted water supply and demand for 1990. Incidentally, I agree that monitoring and testing are vital elements in identifying relationships, and verifying estimates and conclusions. However, our role in the planning process and our regulations require the use of predictive techniques, such as models. Monitoring gives answers after the fact and, in the case of unique systems, without a control situation.

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I suggest that you continue attempting to identify the preferred hydrologic conditions for the Park. There's a good chance these would be compatible with our endangered species objectives. As we suggested in our cover letter with the Biological Opinion, additional clean water may be available on a "rainfall" schedule from the lake, via a vegetated flow-way. We'd be happy to work with you to protect existing water supplies and to expand the scope of the Water Delivery Project to include a flow-way, if those seem to be productive directions.

Sincerely,

Arnold

Arnold Banner, Ph.d.

Enclosure

Your benefits analysis for the Water Delivery Project really is essential! We need it by the end of January

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BASIC RAINDRIVEN
MINIMUM NUMBER OF CELLS FLOODED BY YEAR
(WATER AT OR ABOVE GROUND)

YEAR	CELLS	MONTH
1969	160	MAY
1970	175	DEC
1971	14	MAY
1972	146	APRIL
1973	0	MAY
1974	0	MAY
1975	18	APRIL
1976	54	APRIL
1977	52	APRIL
1978	104	MAY
1979	115	JUNE
1980	141	JUNE
1981	5	MAY
1982	76	APRIL

DISTRIBUTION:

APRIL	MAY	JUNE	DECEMBER
5	6	2	1

FWCA REPORT

APPENDIX H

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

DEC 4 1984

EAST TEXAS STATE UNIVERSITY

Dr. Jonathan D. Moulding
US Army Corps of Engineers
400 West Bay Street
PO Box 4970
Jacksonville Fl 32232

11/8/84

Dear Jon:

Thank you for asking me to review the document dated 17 October 1984, relaying to the Corps the water management position of Everglades National Park. After nearly15 years of research on the biological effects of water management in Everglades National Park, I remain especially interested and concerned with the future management of the Everglades, and so am glad to help when I can. I was particularly interested to read the NPS memorandum of 26 June 1984, of which I had not been made aware. The text of the memorandum is, of course, mostly well known background, about which little need be said. I was pleased to see noted, at least in passing, some of the results of my studies on the relationships of water to animal populations.

Some of my thoughts on water management have been discussed in a couple of papers, which I think may be of use to your staff. It may also be of some value to offer a few additional comments.

The C-111 area is a region that must be of intense immediate concern. You should be aware that the adverse effects of high water levels in this area have been well documented for two species on the Endangered Species List. Increases in the current water depths can in some seasons reduce the reproductive success of the Cape Sable Sparrow in Taylor Slough and the American crocodile in the Taylor River- Joe Bay area. Such potentially serious population effects need to be avoided.

I must note in the positions taken what appears to be a faulty understanding of the causes of the severe problems facing wildlife populations in Everglades National Park over the last two decades of water management. These problems have documentably been caused by too much water at the wrong time. Such excess water has retarded drying rates, adversely affected wading bird nesting, and drowned alligator nests, all indications of an alteration of the natural relationships of the Everglades. Any proposal that fails to decrease the amount of water discharging into Everglades National Park during the late winter to summer will worsen the already precarious position of these populations and further disrupt the natural ecological functioning of the Everglades.

Appendix H:
Letter from J. Kushlan

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Department of Biology, East Texas Station, Commerce, Texas 75428 (214) 886-5366

As you know I have for over a decade supported the concept of returning to the delivery of water by marsh surface flow rather than by canals and the slowing of the downgradient movement of water in Conservation Area 3. In my opinion multiple gated culverts should be installed in L28 (not large scale breaching), S333 should be used to move water into the western part of Northeast Shark Slough, flood protection should be provided to the current residential area by levees and pumping, seasonal farming with attendent risks should be allowed on peripheral areas, L67 canal in Conservation Area 3a should be dammed in many places, L67 extended levee should be completely removed, and L67 extended canal should be back-filled in many and gated culverts be installed.

I must disagree completely with the concept of leaving open all the gates controlling water flow into the park thereby allowing the free flow of water. While such a plan might better reflect rainfall timing, it would not reproduce acceptable amounts of water flow. With the amount of water already resident in the system further north and the increasing amounts to be placed there in the future, the high flows that would result will further deteriorate the southern Everglades ecosystem in the park. I can go further and predict that such a system would exterpate the Endangered Wood Stork as a nesting species in Everglades National Park. The last successful nesting of this species was in a year when we experimentally caused a dry-down by with-holding discharges. The success of this experiment and the failure of the 1984 "experiment" to produce Wood Stork nesting indicate which of the protocols management should follow. By the way,the setting up and subsequent failure of Great Blue Heron and Great Egret colonies is irrelevent as these species are not indicators of properly drying conditions in the Everglades.

I must also disagree with the concept that it is necessary or even desirable that the entirety of the remaining Everglades be restored to some undefinable natural condition. Setting aside the impossibility of the idea, the conservation areas north of the park have as their best managerial function the retention of water for water supply, including the retention of waterin excess of what should flow into the park.

I hope that these brief comments and the papers will be of some help in providing a bit of the insight I have gained in understanding the Everglades. And I hope it will be of some help in your most difficult but crucial task.

Sincerely,

James A. Kushlan, PhD
Associate Professor of Biology

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APPENDIX I

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
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Appendix I.

LEXICON OF MODEL VARIABLES

Following is a lexicon of the variables used by the snail kite and alligator models, and descriptions of how data were reduced for application of the models.

ABTREES: mean distance to the nearest tree or shrub > 2 m tall, measured from random points in the subarea, in meters. Shrubs and trees includes willow thickets and tree islands.

AREA: this was standardized as a one ha subsample, for use in calculating the edge to area of open water index.

BAREVEG: Proportion of the subarea 0-25% covered by emergent/aerial (erect/floating) vegetation. This measures the coverage by vegetation which normally extends above the water surface. Included were sloughs and sparse sawgrass or Eleocharis flats having a bright (periphyton) signature (see spikerush of Olmstead; 2% cover). Sparse sawgrass was that mixed with flats in a reticulated pattern. Sloughs were identified by their intensely dark signature, often adjoining flats, and often having airboat trails extending into or through them.

DENSVEG: Proportion of the subarea > 75% covered by emergent/aerial (erect/floating) vegetation. This includes areas mapped as tree islands and the associated sawgrass. On the black and white transparencies shrubs and trees were not always distinguishable from dense sawgrass, but this was not a problem since both were allocated to the DENSVEG category.

DDEVEL: Proportion of the subarea within 0.5 km of residential or commercial structures. This variable was set to 0 throughout the study area.

DFL1/2: Proportion of the year flooded 1 to 2 m deep. This information was provided by the Corps in the form of isopleths covering the entire study area. Area-weighted means were used to represent each subarea except where values being averaged were on different segments of the suitability curves for a species.

DFL20/1: Proportion of the year flooded 20 cm to 1 m deep. These values were derived from figures provided by the Corps.

DFL550: Proportion of the year continuously flooded 5-50 cm deep. These values were derived from figures provided by the Corps.

DFLDEEP: Proportion of the year flooded over 50 cm deep. These

values were derived from figures provided by the Corps.

DPERMSK: Radial distance to include total of 30 or more ha of permanent wetlands, less than 2 m deep. It was assumed that the canals in the study area were relatively deep. Assuming that just 4 m of the canal cross section was less than 2 m deep, then 75 km of canal was needed to provide 30 ha. The variable measured is the distance from the midpoint of the subarea to the perimeter of the circle including a total of 75 km of canal, or 30 ha of wetland which dries out less often than 6 years.

EDGEOW: Total edge of open water of features over 0.1 ha in area. The edge of open water was determined by first mapping a representative section (1 km sq) in each of the subareas, then taking 6 subsample semi-random quadrats (1 ha each) and measuring the extent of perimeter of slough and adjoining habitat. The value used was the average of the six quadrats.

FLDNEST: Alligators nest in the area, and less than 0.3 are flooded out annually. It was assumed that all of the wetland areas met this qualification, and that only the area around the southeast corner of WCA3A was flooded too deeply for nesting, in the base condition.

FRDRYSK: Number of years between total dry downs. Derived from figures supplied by the Corps.

HIMODVG: Proportion of subarea 51-75% covered by aerial/emergent (erect/floating) vegetation. Two-thirds of the area mapped as uniform sawgrass was placed in this category, as a split between the sawgrass densities from Tanner et al. and from Olmstead and Loope (1984).

IONIC: Salinity in ppt; scored as 0 throughout the study area.

LOWMODVG: Proportion of the subarea 26-50% covered by aerial/emergent (erect/floating) vegetation. One third of the area mapped as sawgrass was placed in this category (see HIMODVG above).

MUD: Proportion of subarea with over one ft of sediment, extending down into the dry season water table. Based on soil depths from Zaffke (1983), and Tanner et al., it was determined that soil depth was non-limiting within the study area.

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FWCA REPORT

APPENDIX J

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-202

JUN 18 1990

AN ASSESSMENT OF

HYDROLOGICAL IMPROVEMENTS AND WILDLIFE BENEFITS

FROM

PROPOSED ALTERNATIVES

FOR THE

U.S. ARMY CORPS OF ENGINEERS' GENERAL DESIGN MEMORANDUM

FOR MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

NATIONAL PARK SERVICE

SOUTH FLORIDA RESEARCH CENTER

EVERGLADES NATIONAL PARK

JUNE 1990

APPENDIX J.

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AN ASSESSMENT OF

HYDROLOGICAL IMPROVEMENTS AND WILDLIFE BENEFITS

FROM

PROPOSED ALTERNATIVES

FOR THE

U.S. ARMY CORPS OF ENGINEERS' GENERAL DESIGN MEMORANDUM

FOR MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

NATIONAL PARK SERVICE

SOUTH FLORIDA RESEARCH CENTER

EVERGLADES NATIONAL PARK

JUNE 1990

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EXECUTIVE SUMMARY

The National Park Service's legal mandate for ecosystem management within Everglades National Park can only be achieved through restoration of a more natural hydrological regime. This restoration of natural surface water conditions should result in at least partial recovery by a broad array of characteristic Everglades animals, both within the park and in the adjacent water conservation areas. This report describes the predicted hydrological impacts and associated wildlife responses for four alternatives proposed under the U. S. Army Corps of Engineers General Design Memorandum entitled *Modified Water Deliveries to Everglades National Park*. This project was specifically designed to provide more natural flow volumes, distribution, and timing of water deliveries to the Shark Slough Basin, with particular emphasis on restoring flows to Northeast Shark Slough. The report contains a detailed review of the overall hydrologic impacts and predicted responses of key, indicator, and endangered species under each of the four alternatives, and for comparative purposes, a hydrologic simulation model of the natural Everglades ecosystem.

Our analyses indicate that the Basic Rain-Driven alternative provided the greatest restoration of natural flow timing, seasonal variability, and flow distributions and the greatest restoration of natural surface water hydropatterns and drying characteristics within the study area. The Basic Rain-Driven alternative was also superior to the other alternatives at mitigating large regulatory releases into the Shark Slough Basin. The Modified Rain-Driven alternative produced the greatest increase in water depths, the largest areas of surface water inundation, and the largest hydroperiod increases throughout the study area. Unfortunately these increases were due to much higher regulatory flows, occurring in response to upstream water management, and were not tied to local rainfall. For this reason, the Modified Rain-Driven alternative did not represent a restoration of more natural hydrological processes. The Base and Modified Base alternatives provided no restoration of natural flow distributions, and produced more biologically destructive regulatory releases because of their strict adherence to the fixed monthly delivery allocations of the Minimum Delivery Schedule, and their inability to divert flows directly into WCA 3B or Northeast Shark Slough.

Major and frequent drydowns in WCA 3B and Northeast Shark Slough, as modeled under the Base and Modified Base alternatives, would adversely impact marsh fish populations, and affect freshwater flows into the downstream estuaries where nesting wading birds feed. Alligator populations would also be adversely affected by these extreme drydowns. Inter-annual effects of major drydowns require several years for recovery of aquatic food webs. Extreme drydown intervals, occurring as frequently as that predicted under the Base and Modified Base alternatives, would prevent such recovery and lead to a downward trend in the system's overall aquatic productivity and its capacity to support higher consumer wildlife populations. The two rain-driven alternatives were more successful at re-establishing longer hydroperiods in central Shark Slough, as well as providing partial restoration of sheet flow to the adjacent higher marshes. These improvements would help to increase aquatic productivity, increase American Alligator nesting success, and re-establish traditional foraging areas for the Snail Kite, Wood Stork, and other wading birds. This re-establishment of more natural surface water inundations and drying patterns would also help to synchronize foraging habitat conditions with the timing of traditional, and historically more successful, wading bird nesting cycles.

The Basic Rain-Driven alternative produced the greatest improvement in critical habitat for both the endangered Snail Kite and Wood Stork. The annual drydown characteristics in WCA 3A under the Basic Rain-Driven alternative resulted in a greater area of surface water inundation for longer periods into the dry season than under the Base alternative. The predicted result of this pattern is that Snail Kites would stay longer in WCA 3A during the dry season under the Basic Rain-Driven alternative than the Base alternative. This was particularly true during the driest, or most severe drought years of the 14-year evaluation period. Longer occupancy in WCA 3A resulted in a decrease in the hypothetical dispersal-related mortality estimates for Snail Kites. The long-term impounding and strict adherence to regulation schedules in WCA 3A under the Base, Modified Base, and Modified Rain-Driven alternatives, produced a degradation of the quantity and quality of Snail Kite primary nesting habitat within WCA 3A. The more natural spatial and temporal hydrologic conditions maintained under the Basic Rain-Driven alternative increased the area of primary Snail Kite habitat.

None of the alternatives reproduced the natural lag in dry season flows to the central and southern reaches of the Shark Slough Basin as predicted in the natural system model. Similarly, all of the alternatives produced complete drydowns in the central slough during five of the 14 years, as compared to only one year under the natural simulation model. This loss of persistent dry season flows, and the resulting reduction of freshwater pools along the coastal mangrove zone, is thought to be the major factor prompting abandonment of the historical wading bird nesting areas within Everglades National Park. Of the four proposed alternatives, the Basic Rain-Driven alternative most closely approximated the timing, seasonal flow volumes, and flow distributions observed under the natural system model. Future improvements to the current rainfall formula targeted at increasing flow volumes during the dry season, combined with the improvements in flow distribution as modeled with the Basic Rain-Driven alternative, would provide the best initial step toward achieving the ecosystem management goals of Everglades National Park.

ACKNOWLEDGEMENTS

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INTRODUCTION

The historical Everglades ecosystem once covered an area of approximately 4000 square miles, extending a distance of over 90 miles from Lake Okeechobee to the estuaries along Florida Bay and the Gulf Coast of Mexico. Since the late 1800's, 36 percent (approximately 1460 square miles) of these historical wetlands have been lost to urban and agricultural development. The majority of these losses occurred during the 1940's and 1950's, with the creation of the Everglades Agricultural Area, south of Lake Okeechobee, and with expanding urban development along the western portion of the Atlantic Coastal Ridge (Fig. 1).

By the early 1960's, an additional 32 percent (approximately 1300 square miles) of the historical Everglades was converted into a series of five water storage impoundments (Water Conservation Areas) which are managed primarily for retention of excess wet season stormwater. An additional 12 percent (approximately 500 square miles) of the historical Everglades wetlands, primarily east of the Water Conservation Areas and within Northeast Shark Slough, have been severely degraded by excessive drainage and invasion of exotic vegetation. The remaining 20 percent (approximately 800 square miles) of the historical Everglades wetlands are managed primarily as wilderness by the National Park Service (NPS), within Everglades National Park and the Big Cypress National Preserve (Fig. 1).

The ecological integrity of the entire Everglades ecosystem has declined over the past several decades. This is evidenced by a 90 percent decline in the number of nesting wading birds, changes in the historical distribution and abundance of higher trophic-level consumer populations, reduced hydroperiods, loss of marsh productivity, increased frequency of alligator nest flooding, and an overall loss of wetland habitats. The general health and continued survival of native wildlife populations within Everglades National Park is at risk unless restoration of naturally functioning ecological processes can be attained.

Several decades of research on the Everglades suggest that many of the current problems within the Everglades ecosystem are directly related to the loss of spatial scale of this wetland system and changes in hydrologic conditions, resulting from construction and operation of the Central and Southern Florida Project. This system of levees, canals, and water storage impoundments divided the original Southern Everglades (south of Alligator Alley) into four distinct hydrological basins (Water Conservation Areas 3A and 3B, Northeast Shark Slough, and western Shark Slough). The hydrological connections among these once-continuous marshes were either severed or strictly limited, in order to control water movement into and out of these artificial basins. As a result, the historical patterns of surface water hydroperiods, seasonal flooding, and sequential drying were disrupted, as were the vegetation and wildlife communities adapted to them.

The timing of declines in wading bird nesting, shifts in nesting areas from Everglades National Park (ENP) to the Water Conservation Areas (WCAs), and abandonment of former feeding grounds correlate with completion of various portions of the Central and Southern Florida Project. Recent studies have shown a strong relationship between longer hydroperiods and increased standing stocks and species richness of aquatic animals. Associated studies have documented the conditions required to make those prey available to top-level predators. Similar studies have shown that prolonged flooding of once shorter hydroperiod marshes, as in southern Water Conservation Area 3A, deters wading bird use and reduces the value and/or changes the timing of these areas as feeding grounds for birds. At the same time, shortened hydroperiods caused by reduced surface water inflows, as in Northeast Shark Slough and Water Conservation Area 3B, have changed formerly rich, central slough habitat into degraded marshes with low standing stocks of fishes and invertebrates, and reduced utilization by wading birds and alligators.

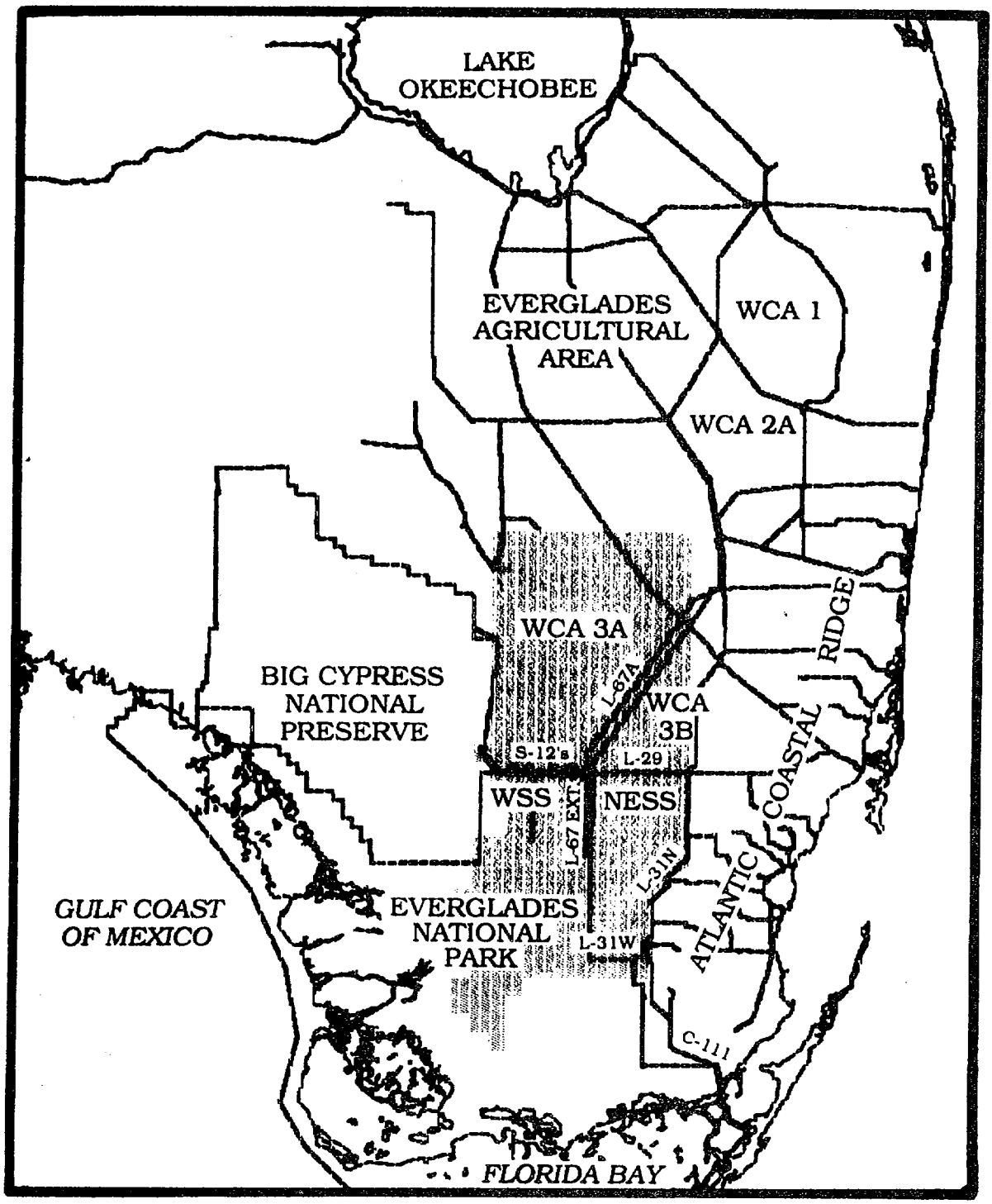

Figure 1. Map of the Everglades ecosystem showing the overall study area (shaded in blue), and the four basins investigated in detail; Water Conservation Area 3A (WCA 3A), Water Conservation Area 3B (WCA 3B), Northeast Shark Slough (NESS), and western Shark Slough (WSS).

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Completion of the levee and canal system around Water Conservation Area 3A shifted surface water flows from the historical eastern flow-way that ran through the lower elevation marshes in Water Conservation Area 3B (WCA 3B) and Northeast Shark Slough (NESS) into the higher elevated marshes in Water Conservation Area 3A (WCA 3A) and western Shark Slough (WSS). This has caused the annual northern Shark Slough dry season pool to form outside the main channel of the slough where it is less persistent and less productive. These structural changes also caused and overall reduction in surface water flows into Shark Slough, which reduced freshwater flows into the downstream estuaries. This resulting loss of freshwater ponding in the headwaters of the Shark Slough and Taylor Slough Basins is thought to be the major factor contributing to the abandonment of historical wading bird nesting sites within the park. Unnatural dry season flood releases through the S-12 structures into western Shark Slough have been shown to disperse aquatic organisms, and disrupt wading bird feeding and nesting. Similar regulatory releases during the early wet season have flooded downstream alligator nests, leading to reduced alligator nesting success (Fig. 1).

The continued diversion of historical surface water flows from WCA 3B and NESS, and the low water levels maintained in the L-31N, C-111, and L-31W canals, to provide increased residential and agricultural flood protection, have overdrained wetlands in the Rocky Glades and the headwaters of Taylor Slough. Both of these areas were traditionally important dry season feeding grounds for wading birds and other key Everglades species. Wildlife populations in these areas will continue to decline until some significant level of restoration of natural hydrologic conditions is achieved.

The purpose of this report is to document the hydrologic impacts and wildlife benefits of four proposed alternatives as defined in the General Design Memorandum (GDM) for Modified Water Deliveries to Everglades National Park, developed by the Jacksonville office of the U. S. Army Corps of Engineers (COE). The overall hydrologic conditions estimated for these four alternatives are compared against a set of hydrologic restoration objectives established at the start of the GDM process, and against the results of a natural system simulation model of the Southern Everglades developed by the South Florida Water Management District (SFWMD). The biological benefits of the four proposed alternatives were evaluated by comparing the required habitat conditions of a selected group of species (wading birds, the American Alligator, and two endangered species - the Wood Stork and Snail Kite) against the estimated hydrologic conditions under the four alternatives, and the results of the natural system model.

PAST HYDROLOGIC CHANGES AND THE NEED FOR FLOW RESTORATION

Numerous hydrologic studies have documented changes in the original spatial and temporal patterns of surface water flows within the Everglades ecosystem (Leach *et al.* 1972, Carter 1974, Blake 1980, Johnson and Fennema 1989). These studies have attributed the majority of these hydrologic changes to the construction and operation of the Central and Southern Florida Project. Man's alteration of the natural Everglades began in the late 1880's with the completion of a flow-way between Lake Okeechobee and the Caloosahatchee River. State funded channelization in the Northern Everglades began in 1908 with construction of the Miami Canal, and by 1924 five major arterial canals were completed between Lake Okeechobee and the Atlantic coast. Large water level reductions were reported in Lake Okeechobee and the Northern Everglades wetlands as a result of uncontrolled drainage through these coastal canals (see Fig. 1).

In the late 1940's, the federal government became involved in water management in the Everglades ecosystem, with the Army Corps of Engineer's work on the Central and Southern Florida Project. By 1953, a nearly continuous levee system was completed along the eastern margin of the Everglades from Lake Okeechobee into southern Dade County. This levee system

reduced surface water flows through the transverse glades that historically discharged stormwater to the Atlantic coast (Parker *et al.* 1955). At the same time, the levee increased flows southward into the eastern Shark Slough flow section. By the early 1960's, the Army Corps of Engineers completed the L-29 and L-67A levees enclosing WCA 3A, and the S-12 structures along the northern boundary of the park. By 1967 the L-67 extension canal and levee were completed along the park boundary between Northeast Shark Slough and western Shark Slough. These changes marked the beginning of managed flows to Everglades National Park, and produced many detrimental impacts on the quantity, distribution, and timing of flows to the park.

Historically, Shark Slough received flows first in the lower lying eastern flow section (L-31N to L-67A), then into the western Shark Slough flow section (L-67A to 40 Mile Bend) as water levels increased. The completion of the L-29 levee below Water Conservation Area 3B cutoff all direct surface water flows into the eastern Shark Slough flow section in 1962. This change in overall flow distributions is shown in Figure 2. For the 21 years of flow records prior to the construction of the L-29 levee, approximately 66 percent of the total annual Shark Slough flow passed through the eastern flow section. In contrast, during a 9-year period in the 1970's, less than 8 percent of the total annual flow passed through this flow section.

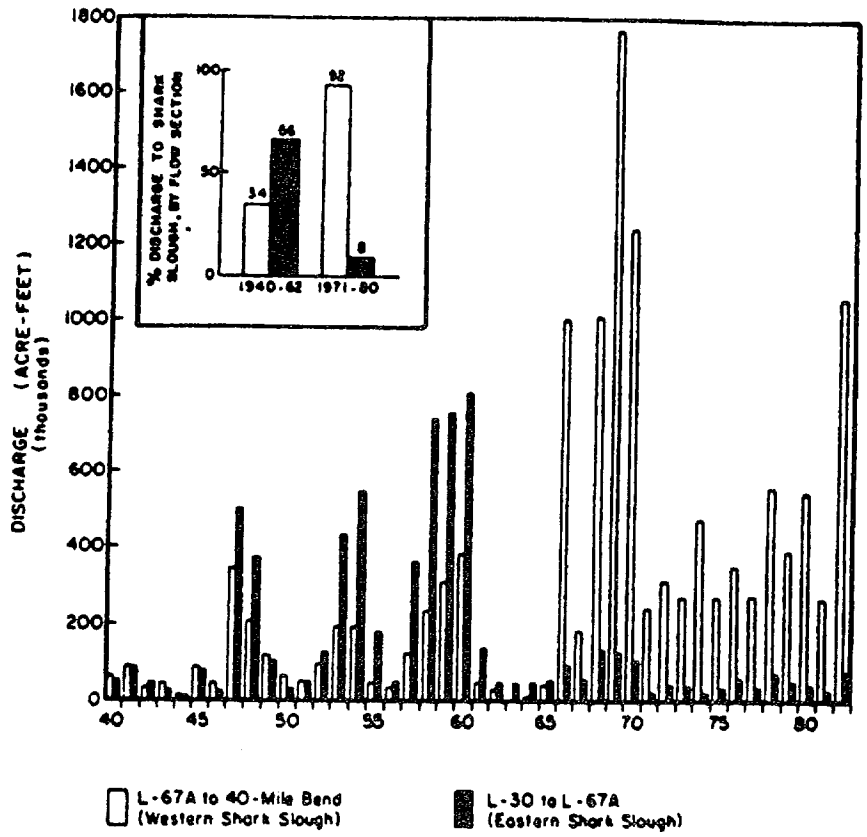

Figure 2. Annual flow distributions for the two Shark Slough flow sections between 1940 and 1982. Source: Wagner, Rosendahl, and Johnson, in prep.

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Completion of the L-67 extension canal and levee also caused drastic hydrologic changes. The levee kept surface water discharges that entered Shark Slough through the S-12 structures from flowing eastward into the main channel of the slough, further isolating the wetlands of Northeast Shark Slough. The excavation of the L-67 extension canal allowed S-12 discharges to be rapidly routed into the central portion of the slough, disrupting natural surface water flow patterns, and leading to an increase in dry season water level reversals.

With the closure of Water Conservation Areas 3A and 3B, surface water flows to Shark Slough became largely a function of upstream water management, rather than responding to natural upstream rainfall and antecedent conditions. During the early 1960's the park experienced its most severe drought on record, in response to below normal rainfall and limited inflows from the upstream Water Conservation Areas. In October 1970, requests from the National Park Service prompted Congress to pass Public Law 91-282, establishing a required monthly Minimum Delivery Schedule for each of the three drainage basins in the park. This schedule established a minimum allowable volume of flow to the park, but it did not address maximum monthly or maximum annual volumes. During the years of 1972, 1973, 1975, 1977, and 1981 the Shark Slough Basin received the required minimum delivery volumes with only minor deviations. For the remaining years, particularly 1982 and 1983, large regulatory releases were made into the Shark Slough Basin.

This strong water management influence on flows into Shark Slough is graphically represented in Figure 3. Extensive rainfall over South Florida throughout the wet season of 1982 and dry season of 1983 caused water levels in WCA 3A to exceed the regulation schedule. Each time this occurred, the S-12 structures were opened full, and large regulatory releases were made into Shark Slough. Large discharges during July and August of 1982 caused widespread alligator nest flooding in the wetlands downstream of the S-12 structures. Similar regulatory flows during February and March of 1983 re-inundated extensive marsh areas making them unsuitable for early dry season foraging by wading birds and other key Everglades wildlife.

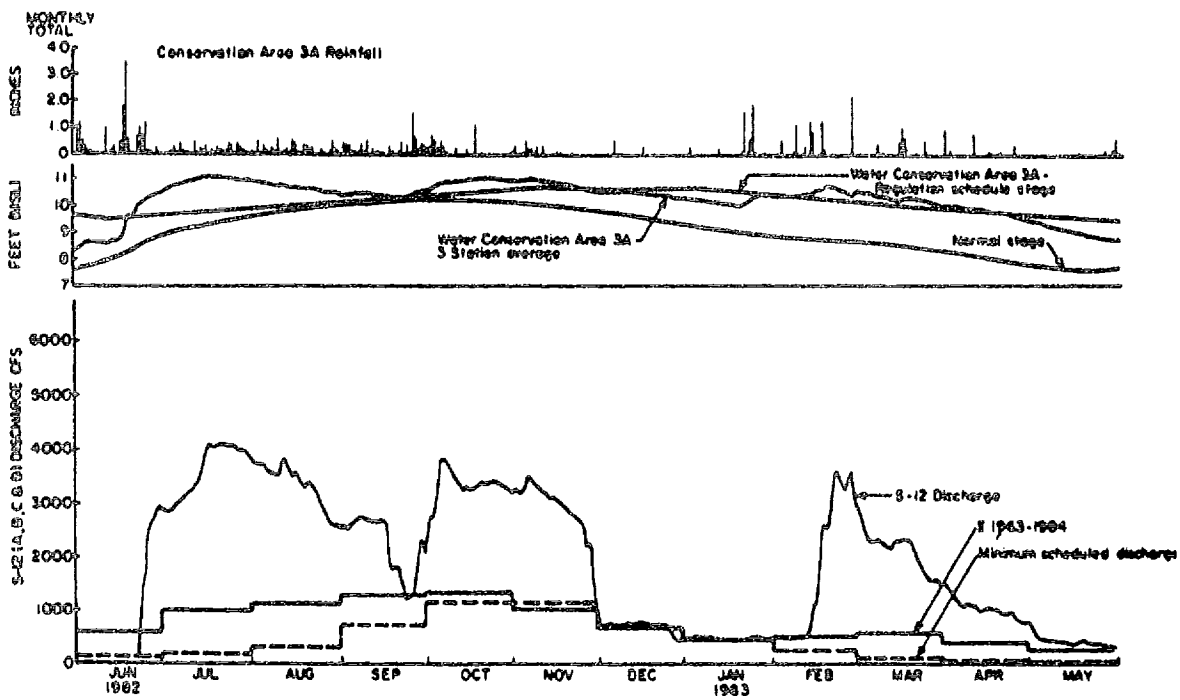

Figure 3. Monthly rainfall and water level in Water Conservation Area 3A in relation to water deliveries to the western Shark Slough Basin through the S-12 structures, June 1982 through May 1983.

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WILDLIFE RESPONSES TO PAST WATER MANAGEMENT

Various alterations in native plant communities and changes in abundance and distribution of key Everglades wildlife species have accompanied the construction and operation of the Central and Southern Florida Project. Enough is known about the habitat requirements of several key Everglades species to show that population declines and detrimental changes in distributions have occurred in response to the loss of wetlands to urban and agricultural development, and changes in the spatial and temporal patterns of surface water within the remaining wetlands. Numerous researchers have stated concerns that Everglades wildlife populations, particularly those with large spatial requirements, will continue to decline until a significant level of restoration of natural hydrological conditions has been achieved.

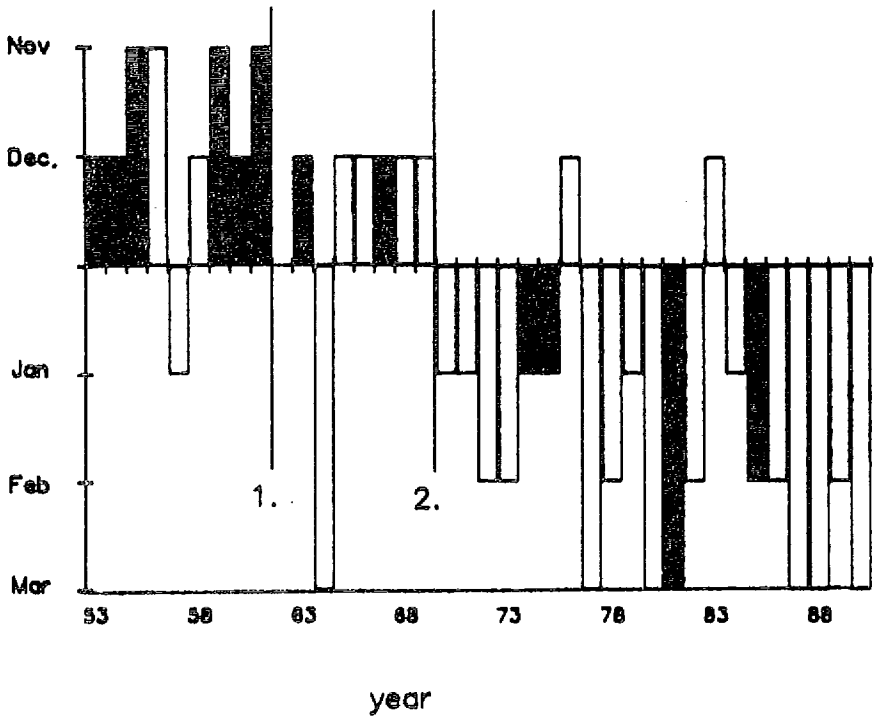
Our best record of wildlife declines in the Everglades ecosystem is for wading birds, and for a few endangered or threatened species with long census histories, or for which relatively detailed anecdotal records have been preserved. Table 1 indicates that the estimated number of nesting wading birds in the interior Central and Southern Everglades has declined drastically since the early 1930's (Robertson and Kushlan 1974, Ogden, in prep.). This decline has increased at an accelerated pace for all species except White Ibis between the mid-1960's and late 1970's. The years with relatively high counts (1931, 1933, 1934, 1940, 1977, etc.) were years in which large numbers of White Ibis nested in the region. The early exodus of White Ibis from the Southern Everglades suggests that these birds are less loyal to traditional nesting sites than other wading bird species, and that they made rapid range shifts in response to relatively subtle environmental changes.

Table 1. Estimated populations of nesting wading birds (Great Egret, Snowy Egret, Tricolored Heron, Little Blue Heron, White Ibis, Wood Storks) in mainland colonies in the central-southern Everglades region of Florida (approximately Alligator Alley south), 1930's to 1989.[1]

Year	Total birds	% ENP	Year	Total birds	% ENP
1931	100,000-125,000	100%	1975	32,000	62%
1932	50,000	100%	1976	38,000	47%
1933	200,000-300,000	100%	1977	45,000-47,000	24%
1934	250,000-300,000	100%	1978	10,000	50%
1935	<25,000	100%	1979	18,000	55%
1936	50,000	100%	1980	4,000	50%
1937	<25,000	100%	1981	11,000	36%
1938	<10,000	100%	1982	17,000	30%
1939	0	----	1983	5,000	87%
1940	150,000	98%	1986	15,000	43%
			1987	17,000	20%
mid 60's	85,000	(est. 85% in 1967)	1988	15,000	38%
			1989	10,000	26%
1974	>12,000-15,000	(no WCA study)			

[1]Because most censuses of wading bird colonies prior to 1986 looked only at "major" colonies, or were not designed to locate small colonies, I excluded small colonies (<100 pair) from the totals for the 1986-1989 census totals. I also excluded Cattle Egrets, again in order to maximize comparability between censuses for all years.

Wood Storks also experienced relatively abrupt changes in overall nest timing and nesting success since the early 1950's. Figure 4 suggests that these major shifts in timing of colony formation and colony nesting success were in response to water management changes that affected water deliveries to the Shark Slough Basin. Many other species of smaller wading birds have been forced to relocate colonies, presumably in response to these same water management events. The last year when large "rookeries" formed in the traditional headwater sites in the park was 1967, and the last, large, successful Wood Stork colony in the park was 1975.



Nesting Success

	succ.(dark)	unsucc.
1953–61	6	3
1962–90	6	23

Colony Formation

	Nov./Dec.	Jan. or later
1953–69	14	2
1970–90	2	19

Figure 4. Timing (by month) of colony formation and colony success, for Wood Storks nesting in Everglades National Park, during the 1953 through 1990 breeding seasons. (1. Completion of the L-29 levee system and the S-12 structures, 2. Completion of the L-67 levee and implementation of the Congressionally mandated Minimum Delivery Schedule).

Among endangered and threatened species, there are good historical accounts which show that under pre-project conditions, both American Alligators and Snail Kites were much more widespread in areas of the remaining Everglades ecosystem than they are presently. Former areas of high alligator densities included Northeast Shark Slough, much of upper Taylor Slough, and numerous, small transverse glades that drained through the Atlantic Coastal Ridge. As recently as the 1960's, alligators were common in the East Everglades west of L-31N (D. Tabb, pers. comm.). Studies by ENP researchers indicate that very small populations, and almost no alligator nesting, now occur in these areas (SRF surveys; South Florida Research Center). Shortened hydroperiods throughout these wetlands during the 1960's and 1970's, as a result of construction of the C-111 canal system, are the primary reason for the sharp reduction in alligators, as well as for the collapse of this region as important, early dry season feeding habitat for wading birds.

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Recent studies by the park indicate that shortened hydroperiods, such as those maintained in the wetlands of Northeast Shark Slough, have adverse affects on the aquatic food chain (Loftus, Chapman, and Conrow, in press). Sampling has shown that the mean number of fishes per square meter in long-hydroperiod marshes in western Shark Slough was 19.3. Compared to 2.3 fishes per square meter in the drained marshes in Northeast Shark Slough. Similar sampling of freshwater prawn give values of 98.0 and 2.3 for the western Shark Slough and Northeast Shark Slough marshes, respectively.

Reports of Snail Kites by early naturalists suggest that they once nested commonly in marshes within the present boundaries of Everglades National Park (W.B. Robertson Jr., ms). A nesting colony was located near the present Royal Palm (Taylor Slough) area of the Park, and Snail Kites were known to roost as far south as Cuthbert Lake island. Although few kites now occur on a regular basis in the interior wetlands of the park, Robertson pointed out that a number of birds, and some nesting, has occurred in th park during recent, prolonged high water periods. This relatively quick response to high water conditions is encouraging, and suggests that kites may re-occupy former range within the park if longer hydroperiods throughout the central Shark Slough can be re-established. An essential goal for all endangered species management programs in the Everglades should be to remove the dependency of any species on relatively small portions of the remaining ecosystem, by expanding the area of suitable habitat.

The wading bird responses reported in Table 1 and Figure 4 also indicate that neither establishment of the Congressionally mandated Minimum Delivery Schedule (1970-1983) nor the current program of Experimental Water Deliveries (1983-present) have produced any discernable recovery in wading bird nesting patterns or population numbers. In fact, the pace of decline by wading birds accelerated under the Minimum Delivery Schedule, while the percentage of breeding waders in the park has continued to decline under the Experimental Water Delivery Program. This suggests that the alterations in water deliveries into Shark Slough to date, have not gone far enough toward restoration of natural hydrological conditions within the basin. The proposed GDM is specifically designed to remove the current structural constrains on water deliveries to Shark Slough, and allow further iterative tests as a way of developing an optimum water delivery formula for the basin.

SOUTHERN EVERGLADES ECOSYSTEM RESTORATION GOALS

The hypothesis guiding our restoration goals is that re-establishment of natural (historical) hydrological patterns of surface water flow volumes, timing, and distribution, and their resulting inundation patterns will substantially increase the total area of biologically productive Everglades wetlands. This restoration of natural surface water inundations, at appropriate locations and times, should result in at least partial recovery by a broad array of characteristic Everglades animals, both within the park and in the adjacent Water Conservation Areas. This hypothesis was developed from two primary sources of information: (1) extensive wildlife studies of the distribution and abundance of several key Everglades species prior to and following construction of the Central and Southern Florida Project, and (2) more recent detailed studies of key Everglades wildlife species, and their associated habitat requirements.

Restoring the original integrity of the Everglades ecosystem, including Everglades National Park, will require basin-wide corrective actions. This approach was first expressed in a statement by the park's research director to the SFWMD governing board in March 1983. At that time the park recommended a seven-point plan of action after large regulatory releases through the S-12 structures during 1982 and 1983 caused detrimental wildlife impacts in the downstream wetlands. A major emphasis of this Seven-Point Plan was the recognition that structural changes were needed to help re-establish natural sheet flow throughout the historic Southern Everglades.

The SFWMD responded by assisting in the initiation of the current Congressionally mandated Experimental Water Delivery Program, and working with the COE and ENP to develop the current General Design Memorandum that addresses the necessary structural changes. This GDM correctly focuses on needed hydrologic improvements both within the park and in the upstream Water Conservation Areas (WCA 3A and WCA 3B). These overall hydrologic restoration objectives are as follows:

1. Allow the volume and timing of surface water flows through the Water Conservation Areas and Everglades National Park to fluctuate naturally in response to rainfall and antecedent hydrologic conditions.

2. Restore more natural surface water flow patterns within Water Conservation Areas 3A and 3B and return to pre-project flow distributions across the entire width of the Shark Slough Basin.

3. Mitigate the detrimental downstream effects of large regulatory releases into western Shark Slough by diverting excess stormwater from WCA 3A into WCA 3B and Northeast Shark Slough.

4. Restore surface water depths and hydropatterns throughout the Southern Everglades as much as possible, to correspond with the natural soil and topographic conditions found in each basin.

5. Improve and maintain the quality of waters flowing through the Southern Everglades, so that the natural resources of the area are not altered or degraded.

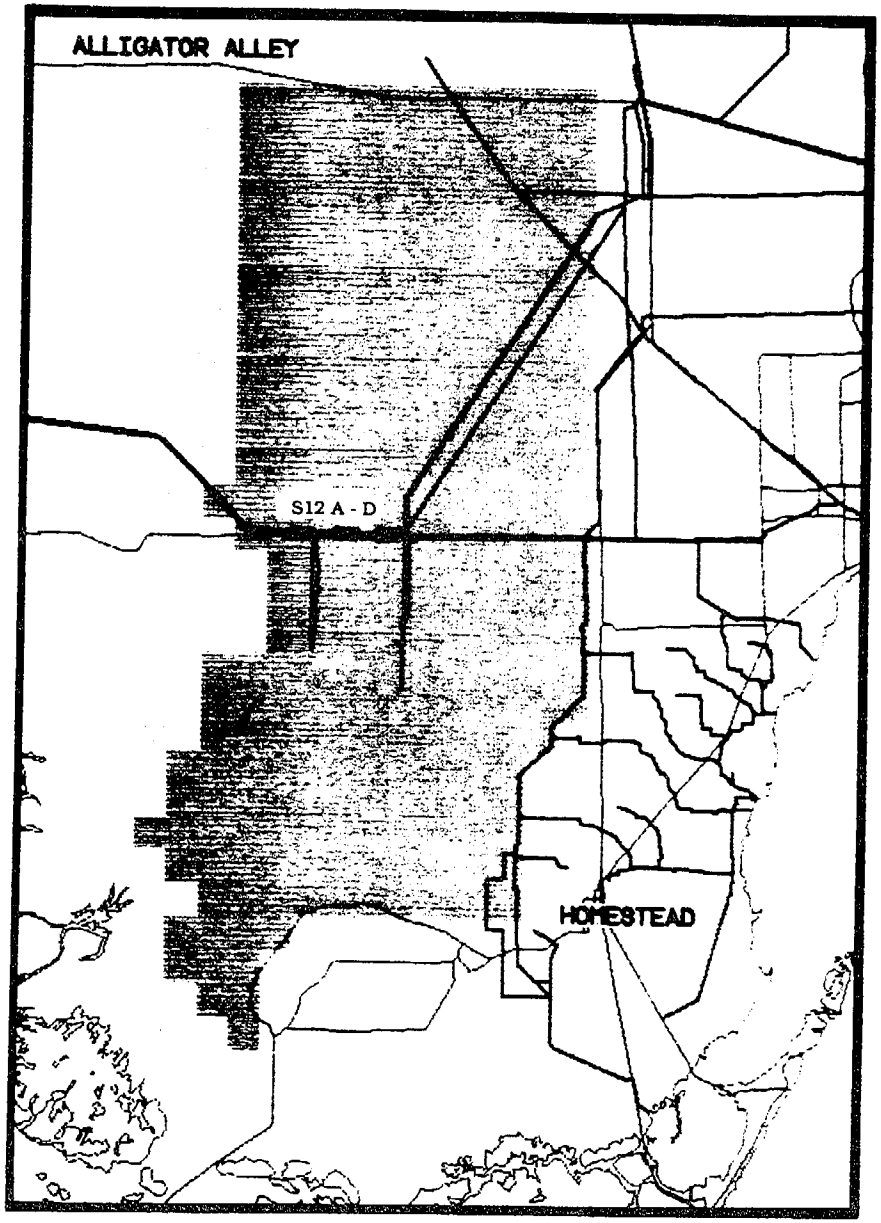
All of these restoration objectives must be met if we are to restore the Everglades to a naturally functioning ecosystem that will support viable populations of historically occurring species.

SUMMARY OF THE PROPOSED STRUCTURAL ALTERNATIVES

The following analysis evaluates the projected hydrological conditions resulting from the four proposed structural and operational water management alternatives with respect to the above stated hydrological restoration objectives and the expected wildlife benefits. The four alternatives evaluated are:

1. Base Condition - This alternative would re-establish water deliveries to Shark Slough following the Congressionally mandated Minimum Delivery Schedule (MDS), and is treated by the COE as the no action alternative (Fig. 5). This and all of the other proposed alternatives include the current drawdown schedule in WCA 2A, large discharges into WCA 3A from the Everglades Agricultural Area following the Lake Okeechobee Operating Permit, and surface water withdrawals based on estimated 1990 land-use and water supply demands.

2. Modified Base Condition - This alternative also re-establishes Shark Slough deliveries following the MDS. The alternative also includes flood protection for the 8.5 sq. mile residential area of the East Everglades, and the removal of L-67 extension levee and canal (Fig. 5). This alternative was developed by the COE at the request of the Vero Beach Office of the U. S. Fish and Wildlife Service (FWS), after they perceived Snail Kite foraging habitat deterioration problems due to reduced hydroperiods in WCA 3A under the Basic Rain-Driven alternative.



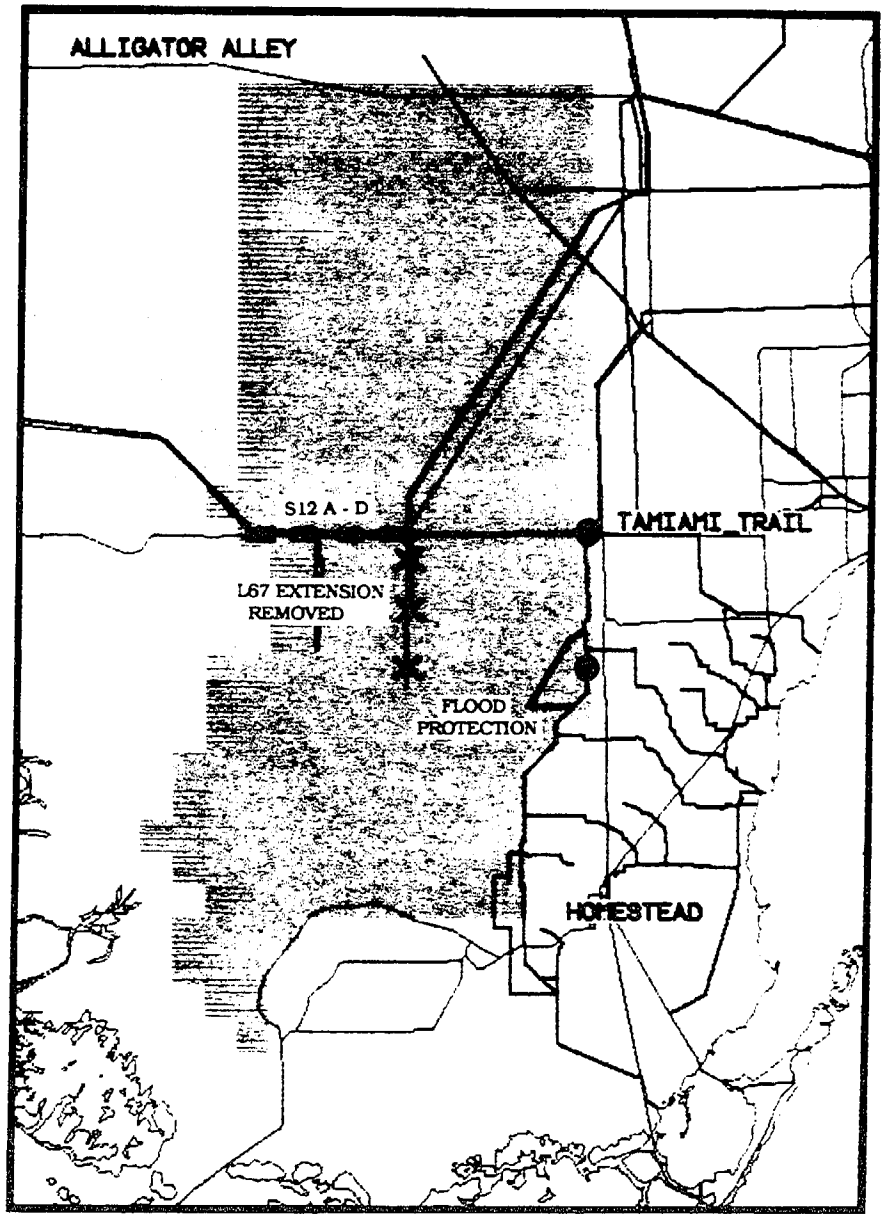


Figure 5. Structural features of the proposed Base (BA) and Modified Base (BC) alternatives.

3. Basic Rain-Driven - This alternative was developed jointly by the COE, the SFWMD, and the NPS to resolve many of the water delivery problems observed in the early 1980's under the MDS. Shark Slough deliveries under this alternative follow the current Rainfall-Driven Delivery Plan developed by the SFWMD. This alternative includes the removal of the L-67 extension canal and levee, flood protection for the East Everglades, new structures (S-345's) to transfer surface water between WCA 3A and WCA 3B, culverts (S-349's) to divert flow from the L-67A canal into the adjacent marsh, and new structures (S-355's) to transfer water between WCA 3B and Northeast Shark Slough, (Fig. 6). This alternative was designed to allow the current Rainfall-Driven Delivery Plan to be fully implemented.

4. Modified Rain-Driven - This alternative includes the same rainfall-driven delivery formula and structural changes as the above Basic Rain-Driven alternative, except for the culverts in the L-67A canal (Fig. 6). The alternative also includes additional surface water inflows into WCA 3A whenever average stages drop below 9.0 feet (current deliveries begin at 8.5 feet) and a forced restriction on outflows when stages fall below 7.5 feet. This alternative was again developed at the request of the FWS, in an attempt to maintain higher dry season stages in WCA 3A for the Snail Kite.

RECOMMENDED APPROACH TO SELECTING THE PREFERRED ALTERNATIVE

At the beginning of the GDM development process, the NPS, COE, and the SFWMD agreed to base much of the selection of the preferred alternative on improved structural flexibility in the delivery of water to Shark Slough. This was done for several reasons. First, the exact hydrologic effects of the proposed alternatives could not be defined from the available COE modeling output. Second, the current rainfall-driven delivery plan appears to need further refinements that can best be made after the plan is fully implemented. Third, preliminary hydrologic and wildlife analyses suggested that none of the proposed alternatives provide for complete hydrologic restoration based on expected wildlife responses and potential water volume problems.

This agreement to design the structural modifications with maximum flexibility allows the system to be operated under any water delivery formula. We further agreed that the selection of a preferred alternative in the GDM would not lock us into a final delivery operational mode, but would allow for continued delivery formula modifications during the latter stages of project development, as additional information became available. The intention was to allow additional iterative water delivery tests to be conducted after completion of the structural modifications in an effort to define an optimum delivery plan.

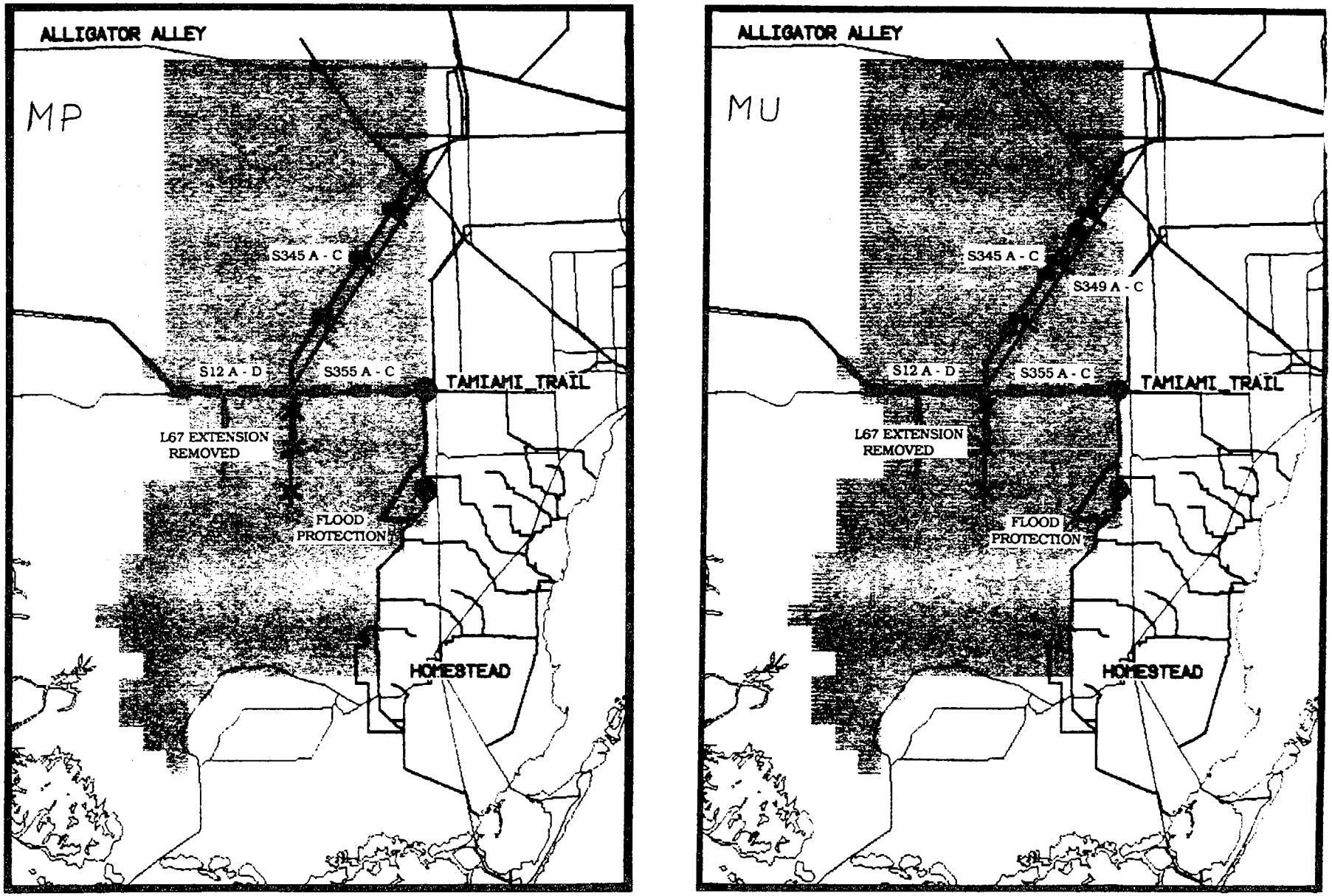


Figure 6. Structural features of the proposed Basic Rain-driven (MU) and Modified Rain-Driven (MP) alternatives.

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METHODS

PREDICTING THE PRE-PROJECT HYDROLOGIC CONDITIONS

Two general approaches were used to define the natural (pre-project) hydrologic conditions within the Southern Everglades, as a way of defining a target for our restoration efforts. The first approach was to compile ground surface elevation and soils data within the study region. These data suggest how surface water would have naturally flowed through the study area, and the general patterns of surface water ponding. The second approach was to review the results of a recent hydrological simulation study designed to reconstruct the hydrological conditions in the natural Everglades ecosystem. The soils information was digitized from a soils association map developed by the University of Florida (Leighty, R. G, *et al.* 1954). The elevation was compiled from information provided by the COE, and from detailed topographic surveys within the freshwater wetlands of the Shark Slough and Taylor Slough Basins done under contract for Everglades National Park. This information was used to define the average ground surface elevation for each modeled grid cell, and to develop a contour map of the overall study area.

The second approach at defining the natural hydrologic conditions within the Southern Everglades was based on examination of the results of hydrologic simulation modeling conducted by the South Florida Water Management District (MacVicar and Johnson, in prep.). The District's natural system simulation model is a modified version of the South Florida Water Management Model (SFWMM), which produces daily water depth data for the same four square mile grid cells as the version of the SFWMM provided by the COE for this GDM analysis. All modeling results were based on the same rainfall data files as in the COE model for the 1969 through 1982 study period. This modeling required major modifications to estimate pre-project conditions including removal of all of the canals, levees, and surface water impoundments in the present system, to allow surface water to flow according to the natural topographic gradients. Many assumptions were made to define this natural system simulation model run including, approximations of the original geometry of coastal drainages, estimation of appropriate evapotranspiration rates for the marshes and adjacent uplands, estimations of inflows from Lake Okeechobee, and an accounting of changes due to peat subsidence and erosion in the original marshes of the Northern Everglades and the Everglades Agricultural Area. Although this model is only preliminary, and much additional fine-tuning is needed, the authors believe that the output does give a reasonable estimate of the general patterns of surface water flows through the Southern Everglades, that would have occurred under natural hydrologic conditions.

PREDICTING THE HYDROLOGIC IMPACTS OF THE FOUR ALTERNATIVES

A version of the South Florida Water Management Model, developed by the South Florida Water Management District and operated by the U.S. Army Corps of Engineers, Jacksonville District, was used to obtain estimated marsh hydrologic conditions under each of the proposed alternatives. The COE provided estimated end of month water levels throughout the study area, and monthly total flows at selected points for a 14-year period from January 1969 through December 1982. This 14-year test period was used as the basis for all of the comparisons between the proposed alternatives.

Monthly water depth distribution maps for all four alternatives were generated from the water level and topographic data themes for the evaluation area. The raw data consisted of average ground surface elevations and average water levels (feet above mean sea level) for two mile by two mile grid cells which covered most of Southern Florida. All data were imported into the park's MASSCOMP computer and entered into a Geographical Resources Analysis Support System (GRASS) based Geographic Information System (GIS).

The basic strategy involved in this process was to first create GRASS data themes of ground surface elevation and water level (a separate file for each date/model-type). The first theme developed was for ground surface elevation. This was done by importing the COE's topographic data into GRASS and deleting the portion of the study area that was surveyed by the park. The next step was to patch in the park's topographic data. This combined ground surface elevation theme was then used in the surface subtraction process described below. Next, the end of month water level data for the entire 14-year period for each alternative were imported into GRASS. The ground surface elevation theme was then subtracted from each water level theme, resulting in a water depth theme for each date and model alternative.

The water depths for each theme were reclassified into six water depth classes (Table 2). These reclassified water depth themes were then output as color maps of the study area, with each color representing a different water depth class. The intervals selected for these water depth classes were chosen on the basis of the observed level of resolution that could be expected from the model output, based on a review of the District's model calibration and verification report (MacVicar, VanLent, and Castro 1983). Each theme was plotted for the entire study area and/or summarized in a series of printed reports for each sub-basin (Fig. 1).

Table 2. Water depth classes used to analyze projected surface water conditions from the hydrological model output.

Class	depth interval (feet)	Map Color
1	below ground, dry	Brown
2	0.00 to < 0.50	Yellow
3	0.50 to < 1.00	Green
4	1.00 to < 1.50	Lt. Blue
5	1.50 to < 2.00	Med. Blue
6	2.00 ft. or greater	Violet

The water depth themes were next combined to produce annual surface water hydroperiod themes for each hydrologic year (June through May). Each of these themes were reclassified into 13 hydroperiod classes (Table 3). These hydroperiod themes were then output as color maps of the area, similar to the water depth maps. In addition to the color maps, summary reports were generated for each sub-basin. This information was processed into a series of databases for the end of month water depth and annual hydroperiod data for each of the four sub-basins, under all of the proposed alternatives. Monthly, seasonal, and annual values for 16 surface water parameters were then calculated from these raw data files for each alternative throughout the 14-year evaluation period. Basic descriptive statistics (means, medians, standard errors, etc.) were then compared for each of the surface water parameters to identify any statistically significant differences in surface water conditions among the alternatives.

Table 3. Surface water hydroperiod classes used to analyze the projected surface water conditions under the four alternatives.

Class	depth interval	Map Color
0	no hydroperiod, dry	Dk. Brown
1	1 month hydroperiod	Med. Brown
2	2 month hydroperiod	Lt. Brown
3	3 month hydroperiod	Dk. Yellow
4	4 month hydroperiod	Med. Yellow
5	5 month hydroperiod	Lt. Yellow
6	6 month hydroperiod	Med. Green
7	7 month hydroperiod	Lt. Blue
8	8 month hydroperiod	Turquoise
9	9 month hydroperiod	Med. Blue
10	10 month hydroperiod	Dk. Blue
11	11 month hydroperiod	Purple
12	12 month hydroperiod	Violet

PREDICTING THE BIOLOGICAL IMPACTS OF THE PROPOSED ALTERNATIVES

The end of month surface water depth maps, annual hydropattern maps, raw data reports, and summary descriptive statistics generated by the hydrologic analyses were evaluated in relation to hydrological conditions that are known or are predicted (based on supporting data) to provide improved wildlife habitat, food availability, or nesting conditions. The first step in this analysis was to use all available data on selected species or groups of organisms (i.e., wading birds, American Alligators, Wood Storks, and Snail Kites) to identify habitat conditions important to supporting these populations.

Recorded observations of wading bird nesting and foraging patterns within Shark Slough, WCA 3A and WCA 3B, since the 1950's, were reviewed relative to known changes in habitat conditions. Data collected over the past several years on fish and aquatic invertebrate densities in short and long hydroperiod marshes of Shark Slough were used to define marsh conditions that supported increased abundance and species richness of these organisms. Information on the distribution and abundance of wading birds and alligators, collected during 1984 through 1990 using the SRF aerial survey methodology, were reviewed relative to overall spatial habitat conditions in the Central and Southern Everglades. In addition, extensive reviews were made of the available published literature on Everglades wildlife.

Biological Submodels (Wading Birds and American Alligator)

Two dominant consumer elements of the Everglades fauna were selected as indicators of system function: the American Alligator and nesting wading birds. An alligator population submodel and a wading bird colony site submodel, components of an Everglades ecosystem simulation model (developed by a team of system modelers and Everglades researchers) were used in this analysis to evaluate the four proposed water delivery alternatives. Populations of

the selected indicator species have experienced significant declines from former levels of abundance and distribution within the GDM evaluation area. The impacts of each proposed water delivery alternative on these indicator species were assessed by comparing the biological submodel responses to each of the four proposed alternatives. Responses of these same submodels to the natural system simulation model runs for the GDM evaluation area were also compared to those of the four proposed alternatives.

Alligator Population Submodel

Population parameters used in the alligator submodel are listed in Tables 4A through 4C. Alligator nesting densities in response to soil type and water depth during the mating period were empirically derived (Fleming, in prep.). Cohort survival rates were estimated from both published and unpublished data sources (Kushlan 1986, Dalrymple 1989). Antagonistic mortality estimates were based on field observations (Fleming, unpublished data) and from the general literature. The model assumes a stable age distribution at the beginning of each 14-year simulation run. Nesting success is based upon both constant (infertility, predation, desiccation, etc.) and variable sources of egg mortality (nest flooding) as documented by Kushlan and Jacobson (1984) and Fleming (In prep.).

Table 4A. Alligator cohort survival rates by age class.

	Age Classes						
	1	2	3	4	5	6	>6
Survival Rates	0.7	0.7	0.8	0.8	0.8	0.8	.95

Table 4B. The number of alligator nests/100 acres related to water depth and soil type.

	Water Depth Classes (feet)			
Soil Type	0 < 0.5	0.5 < 1.0	1.0 < 1.5	> 1.5
Inorganic Marls and Sands	2.0	2.2	6.3	4.0
Organic Peats	4.5	8.9	9.9	6.5

Table 4C.Alligator cannibalism parameters.

Maximum rate per year	=	0.2
Half saturation rate	=	1.0
Exponent for sigmoid cannibalism response	=	4.0
Healthy adult monthly food requirements (kg)	=	4.5

Wading Bird Colony Site Submodel

The wading bird colony site submodel predicts annual nesting success at a colony site based on a core foraging radius around that site and two surface water parameters: (1) the areal extent of shallow water within the core foraging radius of the colony site (as a percentage of the core area),and (2) the duration of this shallow water condition (number of months). Default settings of the model for these three parameters are: a 20 km foraging radius, 22 percent areal extent of shallow water, and a minimum two months duration of shallow water. These values were empirically derived (Bancroft *et al.*, in prep.; Fleming *et al.*, in prep.[a]).

For this analysis, initiation of nesting at a colony site is modeled to occur during the first dry season month in which 22 percent or more of the area within 20 km of the colony site had water depths (ranging up to one foot) suitable for efficient wading bird foraging. If this surface water condition was maintained in the model run for at least two consecutive months following nesting initiation, successful nesting is then predicted at the colony site for that year.

Snail Kite Assessment in WCA 3A

A detailed comparison of the drydown and inundation characteristics within WCA 3A under the four proposed alternatives was made to determine their impact on the Snail Kite. To compare the number and severity of annual drydown occurrences in WCA 3A for each alternative, estimates of surface water area remaining in WCA 3A the last month of each annual drydown were divided into five-percentile drydown classes. The number of annual drydown occurrences per cumulative percentile drydown class for each delivery alternative was also determined for the 14-year period. The number of annual drydowns per cumulative percentile class for each alternative was divided into 14 (number of years in evaluation period) as an estimate of the average interval between drydowns of a given severity.

Population Simulation Modeling

No attempt was made to develop a Snail Kite population simulation model to predict impacts of the proposed water delivery alternatives on Snail Kite demographic patterns. The lack of adequate data on Snail Kite mortality and on proportions dispersing during annual drydowns would have resulted in the development of a model with low realism and utility for risk analysis assessments of the proposed alternatives. In an initial assessment of the potential delivery impacts on Snail Kites in WCA 3A, the FWS related the number of Snail Kite dispersal

sightings reported by "Hotline" each month (Takekawa and Beissinger 1989) during the 1985 drydown of WCA 3A to validation model run estimates of monthly surface water area remaining in the basin at the end of each month of 1985 dry season. The FWS developed a dispersal curve by regression analysis to relate those two data sets. Because sampling effort was not standardized in searching for, and reporting dispersed kites, and because of large errors in validation model run estimates of actual surface water conditions in WCA 3A, the resulting dispersal curve is of low utility in estimating Snail Kite dispersal tendencies. A possible refinement of this approach for assessing delivery impacts on Snail Kite dispersal tendency from WCA 3A would be to use actual empirical estimates of monthly surface water area in WCA 3A (NPS unpublished data) for the 1985 dry season months (available from Audubon and NPS systematic reconnaissance flight data). For the present analysis, empirical data were used to develop a more accurate regression curve of Snail Kite dispersal tendency from WCA 3A during annual drydown events.

Reported Snail Kite dispersal sightings for each month, as used by the FWS in developing the regression dispersal curve, included an unknown number of new or previously dispersed birds. Estimates of Snail Kite temporal dispersal patterns cannot be directly derived from the number of Snail Kite dispersal sightings predicted by the dispersal curve without first making an initial assumption concerning dispersal-related mortality. In this analysis, an initial assumption of no mortality for dispersing birds was made to derive hypothetical, sample populations of dispersed kites that modeled the different predicted temporal dispersal tendencies of Snail Kites in relation to the drydown characteristics of WCA 3A for each of the proposed alternatives. The first step in the analysis was to predict the number of dispersed kite sightings for each month of the drydown, by applying the dispersal curve to the model generated estimates of the amount of surface water remaining in WCA 3A at the end of each month.

The hypothetical population of newly dispersed birds for each month was then generated by subtracting the predicted number of dispersed kite sightings in the previous month from the predicted number of birds sighted in the current month. This calculation procedure reflects the initial assumption (of no mortality) that the number of Snail Kites sighted in any drydown month will include any birds that had dispersed earlier in the drydown. If a reversal or stall in drying had occurred, in the previous month, the estimate of the number of newly dispersed birds was set to zero.

Application of Hypothetical Mortality Models

Since no empirical data exist for Snail Kite dispersal-related, dry season mortality, a set of hypothetical mortality curves, representing a wide range of possible mortality patterns, was applied to the predicted temporal dispersal patterns of kites derived for each of the proposed water delivery alternatives. Mortality patterns examined included constant, increasing, and decreasing/increasing rates over the drydown period. It is important to note that the actual mortality rate values used were hypothetical, and do not necessarily reflect the actual mortality rates which would be experienced by the kites. For these analyses, the relative differences are important, not the actual magnitudes calculated. The resulting relative mortality estimates for each alternative were then compared to assess their overall drydown impacts on predicted Snail Kite dispersal-related mortality.

Two methods were used to estimate monthly dispersal-related relative mortality for each hypothetical mortality pattern examined. Relative mortality estimates were modeled either as a simple function of the number of days a bird was dispersed during the drydown period (Type I) or as a function of the calender month(s) during which a bird was dispersed (Type II). To

assess the impacts of the proposed alternatives on maintenance of long-term Snail Kite critical habitat within WCA 3A, the proportion of the basin within the upper and lower limits of average drydown intervals required to maintain Snail Kite habitat were calculated.

The two key habitat variables selected for comparison were: (1) the proportion of WCA 3A that was maintained at or above the average minimum drydown interval (1.6 years) required to support stable and ample populations of Apple Snails, the principal prey of Snail Kites, and (2) the proportion of WCA 3A maintained within the upper limit of average drydown intervals (5.0 years) required for the persistence of woody plant communities, the most successful nesting substrates for Snail Kites. Long-term Snail Kite suitable habitat was defined as the area of WCA 3A that fell within the upper and lower limits of average drydown intervals required to maintain the prey base and woody plants. The GIS data files containing the average drydown intervals calculated for each grid cell of the study area, for each alternative during the 14-year evaluation period were used to define the location and spatial extent of habitat within WCA 3A that met these criteria.

Methods based on Nesting Ecology Parameters

Factors favoring Snail Kite nesting success in WCA 3A were developed in coordination with two Snail Kite experts (R. Bennetts and J. Rodgers). Water depths of 9 inches (20 cm) or greater around the nest site and foraging areas at the time of nesting initiation, with surface water durations lasting throughout the nest-building (10 days), incubation (27 days) and nestling period (30 days), were selected as the most critical parameters for nesting success. Past studies have documented that the peak kite nesting initiation period in WCA 3A occurs from January through April each year, and that most foraging by nesting pairs occurs within a one-kilometer radius of a nest site (Bennetts *et al.* 1988, Snyder *et al.* 1989). All of these findings were used to formulate the evaluation criteria listed below.

Four indices of favorable surface water conditions for nesting success within Water Conservation Area 3A were proposed. These criteria were then compared to the surface water conditions in WCA 3A estimated for the Base and Basic Rain-Driven alternatives These four proposed criteria are:

1. The area of surface water within WCA 3A remaining at the end of February with water depths of 12 inches (30 cm) or more, that also retained surface water for the next two consecutive months (61 days);

2. The area of surface water within WCA 3A remaining at the end of February with water depths of 16 inches (40 cm) or more, that also retained surface water for the next two consecutive months (61 days);

3. The area of surface water within WCA 3A remaining at the end of March with water depths of 9 inches (20 cm) or more, that also retained surface water for the next two consecutive months (61 days);

4. The area of surface water within WCA 3A remaining at the end of March with water depths of 12 inches (30 cm) or more, that also retained surface water for the next two consecutive months (61 days).

The months of February and March were selected since occur within the middle of the peak nesting initiation period. Certain adjustments to these criteria were made to fit them to the available study data. The 61 day duration was required since the water level data provided for the GDM evaluation process was for the end of each month. Similarly, the two mile by two mile grid resolution should include the majority of the foraging areas adjacent to a nest site.

RESULTS

ESTIMATED PRE-PROJECT HYDROLOGIC CONDITIONS

The results of the soils and ground surface elevation analyses are displayed in Figure 7. The dark green areas in the center of Shark Slough, and throughout much of WCA 3A and WCA 3B, represent areas underlain by Everglades and Loxahatchee peat (muck) soils, formed under extended periods of annual surface water inundations (Gleason *et al.* 1984). The orange colored area on the western side of Shark Slough is underlain by low-organic marl soils that apparently formed under short to intermediate hydroperiods. The bright yellow areas are underlain by similar organic marl soils that define the headwaters of Taylor Slough wetlands. These marls also formed under short to intermediate hydroperiods. The light brown areas east of Shark Slough represent the Rocky Glades. This area has extensive exposed limestone outcrops with shallow, inorganic sandy soils, and was apparently inundated only under high water conditions at the peak of the wet season. The dark brown areas represent the higher elevated Atlantic Coastal Ridge, a weathered limestone complex with very thin, sandy loam soils. Finally, the bright blue areas at the top and lower left corner of the map are unclassified peat and marl soils which were not mapped within Broward and Monroe Counties.

The soils and elevation data clearly define the natural features of the area, and suggest how surface water would have flowed through the study area in the absence of the current system of canals and levees. A low-lying, eastern flow-way, traversing from northeast to southwest through WCA 3B and Northeast Shark Slough into the downstream estuaries of western Shark Slough, is clearly defined by the elevation contours and the underlying peat soils. This suggests that under natural conditions, a pool of deep water would have formed seasonally along this eastern flow-way, which presumably would have maintained flows through the central slough and into the downstream estuarine areas of Shark Slough.

The elevation contours similarly indicate that as water levels increased above 6.5 feet, surface water would progressively inundate western Shark Slough and WCA 3A. Once water levels reached 7.5 feet, surface water would spread across the entire Shark Slough flow section. This higher elevated area within western Shark Slough is clearly defined by the short to intermediate hydroperiod sandy marl soils, downstream of the S-12 structures. All of this information indicates that the western Shark Slough flow section historically received much less water than it does under current water management. Finally, the ground surface contours suggest that large areas of the higher elevated marshes within the Rocky Glades would have been inundated whenever water levels exceeded approximately 6.0 feet.

The water depth and surface water flow data from the District's natural system simulation model were also used to make general hydrologic comparisons with the results of the four proposed alternatives developed in the GDM. This analysis worked well since the four proposed alternatives were developed using a version of the same model. Figures 8A and 8B are the estimated surface water depth maps of the study area generated by the District's natural system model. Figure 8A shows the expected surface water depth and flow patterns at the peak of the wet season during a selected normal hydrologic year (October 1976). This wet season map shows that a core of deep surface water (the blue colors represent water depths in excess of 1.0 feet) formed along the eastern flow-way that runs northeast to southwest through WCA 3B and into Northeast Shark Slough. This eastern flow-way extends the entire length of the Shark Slough Basin and into the downstream estuaries. A large pool of deep water (the dark blue color represents water depths in excess of 2.0 feet) also formed along the headwaters of Shark River. The map suggests that at the peak of the wet season, surface water inundated all of WCA 3A and the Rocky Glades, but that water depths were generally less than 1.0 feet (represented by the yellow and green colors).

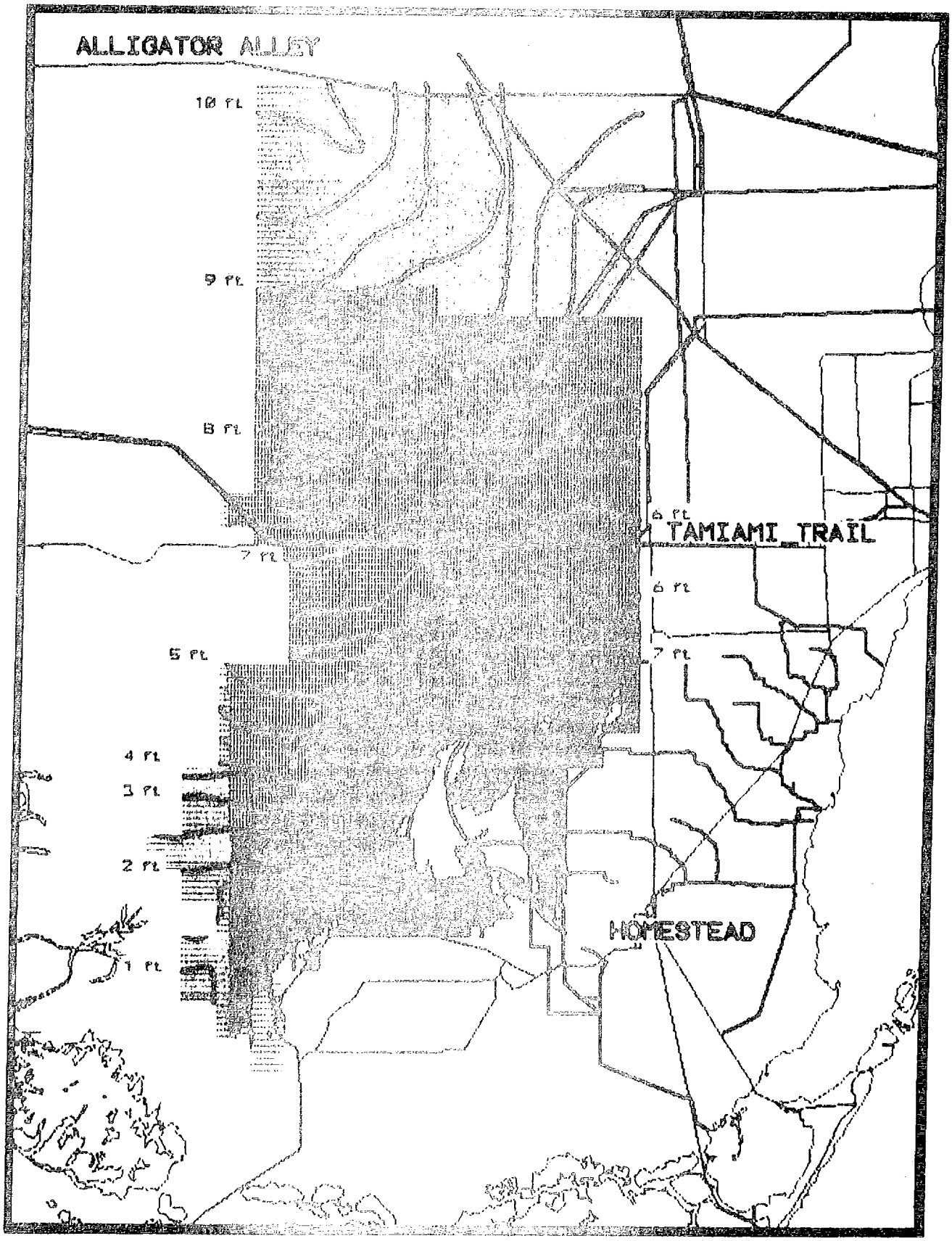

Figure 7. Soils and ground surface elevation map of the overall study area.

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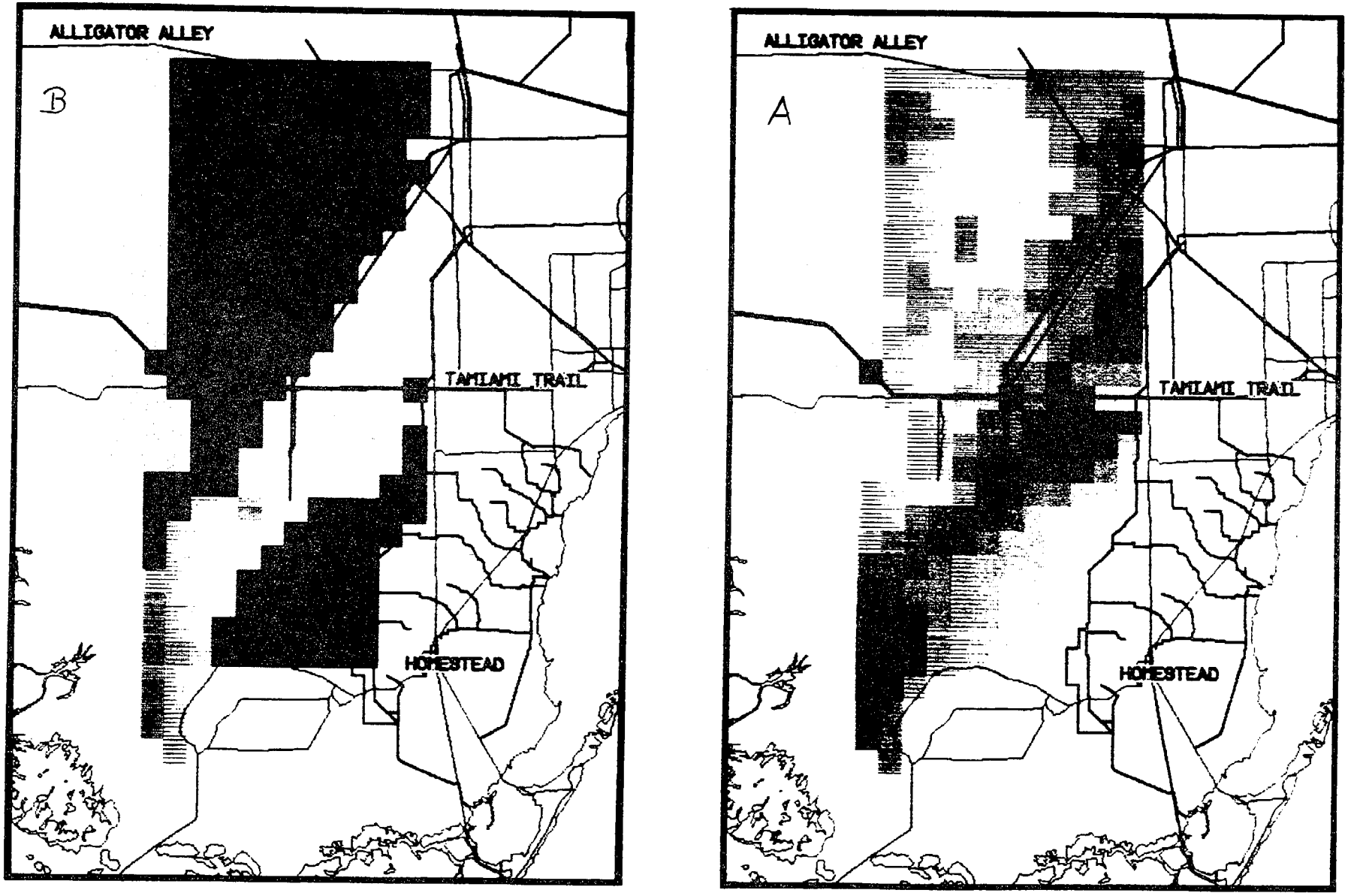

Figure 8. Surface water distribution maps for (A) average wet season and (B) average dry season conditions based on the natural system simulation model. Table 2 indicates the generalized water depth classes used in this analysis.

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Figure 8B shows the expected surface water pattern at the end of the dry season during the same normal year (April 1977). You should note that the overall rainfall and surface water conditions during April 1977 were slightly dryer then normal. This dry season map shows a similar core of shallow surface water, following the eastern flow-way from WCA 3B, through Northeast Shark Slough, and into the downstream estuarine areas of Shark Slough. The model estimated that all of the higher elevated marshes of WCA 3A, western Shark Slough, and the Rocky Glades would have drained completely by the end of April 1977. Also note that the only areas of extensive deeper water occurred in the headwaters of Shark River and the downstream estuaries.

A number of general conclusions can be drawn from observations of the water depth and surface water flow estimates produced by this natural system simulation model. Under natural conditions, nearly all of the Southern Everglades was inundated during the wet season due to local rainfall over the Everglades Basin. During wetter years Lake Okeechobee would overflow its southern shore and contribute additional flows to the Northern Everglades. This surface water would slowly flow through the wetlands, eventually reaching the coastal mangrove estuaries along Florida Bay and the Gulf of Mexico. The slow surface water flow rates in these natural marshes attenuated the discharge spikes that are common under current management, and produced more gradual flow increases and longer recession periods.

The slower surface water flow rates also caused much of the wet season rainfall in the Northern Everglades to reach the Shark Slough Basin during the following dry season. This long lag-time for discharges reaching the park helped maintain surface water flows down the historical eastern flow-way throughout all but the driest years. The persistence of these surface water flows supported the large pool of surface water found along the headwaters of the Shark River. The loss of these persistence flows and the resulting reduction of freshwater along the coastal mangrove fringe is thought to be the major factor prompting abandonment of the historical nesting areas within Everglades National Park.

HYDROLOGIC ASSESSMENT OF THE FOUR PROPOSED ALTERNATIVES

Restoration of Natural Flow Timing and Variability

Under natural, unmanaged conditions, surface water flows into and through the Southern Everglades were driven by rainfall and the antecedent conditions in the upstream basins. One of the most important objectives of the park's original request for the GDM modifications was to restore the natural variability in the volume and timing of surface water flows to the Southern Everglades.

Water deliveries to the park following the Congressionally mandated Minimum Delivery Schedule, as applied in the Base and Modified Base alternatives, are made according to a fixed monthly allotment that does not vary with the current rainfall or antecedent conditions. If the timing and magnitude of rainfall and evaporation are close to the long-term average conditions during a particular month, the scheduled releases will mimic the natural system's response. During periods when the weather conditions are variable (which is the general character of Everglades weather patterns) the scheduled releases do not follow the natural system's response. The only variability that can occur under this delivery schedule is during flood conditions, when WCA 3A stage exceeds regulation and the S-12 structures are opened full, or during a declared drought, when the park receives a fixed percentage of the total available water.

Water deliveries to the park following the District's Rainfall-Driven Plan, as applied in the Basic Rain-Driven and Modified Rain-Driven alternatives, are made according to a multiple regression formula that relates the current week's discharge to the previous week's discharge and to rainfall and evaporation conditions during the previous ten weeks. A study by the District (Neidrauer and Cooper 1989) indicates that this model does not accurately predict the actual flow volumes during the calibration period (1941-1952) but it does capture the overall rainfall response and variability of discharges to Shark Slough. One important reason for this formula's ability to respond to local rainfall conditions is the weekly time step. This allows flow conditions to vary in response to short-term weather conditions. The Rainfall-Driven Plan also has a regulatory component which adds additional flows to Shark Slough whenever the storage capacity in WCA 3A is exceeded.

Monthly discharge hydrographs for surface water flows into Western Shark Slough (L-67 to 40 Mile Bend flow section), Northeast Shark Slough (L-31N to L-67 flow section), and from WCA 3A into WCA 3B (proposed S-345 structures) are shown in Figures 9 and 10 for three of the model alternatives, the Base Condition, Basic Rain-Driven, and Modified Rain-Driven over the 14-year test period. The fourth alternative, Modified Base is omitted since the monthly flow totals are generally within 2000 to 3000 acre-feet of the Base Condition monthly totals, because These two alternatives have the same operational criteria for flows to the park.

The most obvious visual differences between the discharge hydrographs for the three alternatives is the absence of flows through the Northeast Shark Slough and WCA 3A - WCA 3B flow sections under the Base alternative. That is because this alternative does not include any new structures to move water between WCA 3A and WCA 3B, and the Minimum Delivery Schedule calls for all Shark Slough water deliveries to pass through the western flow section. For this reason, flows into and through WCA 3B and Northeast Shark Slough are not tied to local rainfall under the Base and Modified Base alternatives. In contrast, surface water flows into and through these two flow sections under the Basic Rain-Driven and Modified Rain-Driven alternatives based on the Rainfall-Driven Delivery Plan, and are controlled primarily by rainfall over WCA 3A.

Examination of the volume and timing of monthly flows through the Western Shark Slough flow section (L-67 to 40 Mile Bend) indicates that the Basic Rain-Driven and Modified Rain-Driven alternatives exhibited a greater degree of seasonal and annual variability than the Base and Modified Base alternatives. The Base and Modified Base alternatives produced abrupt seasonal spikes with rapid flow increases occurring each year between July and August, regardless of the timing of local rainfall. In contrast, flows under the Basic Rain-Driven and Modified Rain-Driven alternatives showed a more gradual rise in response to the start of wet season rainfall (reduction in abrupt spikes) and the timing of these flows varied annually in response to the observed rainfall conditions. In the absence of large regulatory releases, flows under the Base and Modified Base alternatives consistently peaked in October and decreased at a fixed rate through January. In contrast, under the Basic Rain-Driven and Modified Rain-Driven alternatives, the timing of wet season peaks and the length of the recession curves varied each year in response to the cessation of rainfall.

Rainfall and surface water flows under the Base and Modified Base alternatives were least synchronous during low rainfall periods in the late wet season or early dry season (such as 11/70-4/71, 7/72-10/72, and 9/80-3/81). At these times, discharges to Shark Slough were made when downstream stages were naturally receding in response to low rainfall. In addition to the problems that these higher discharges had on wildlife, the additional flows would require deliveries from upstream areas or cause further depletions of water storage in WCA 3A.

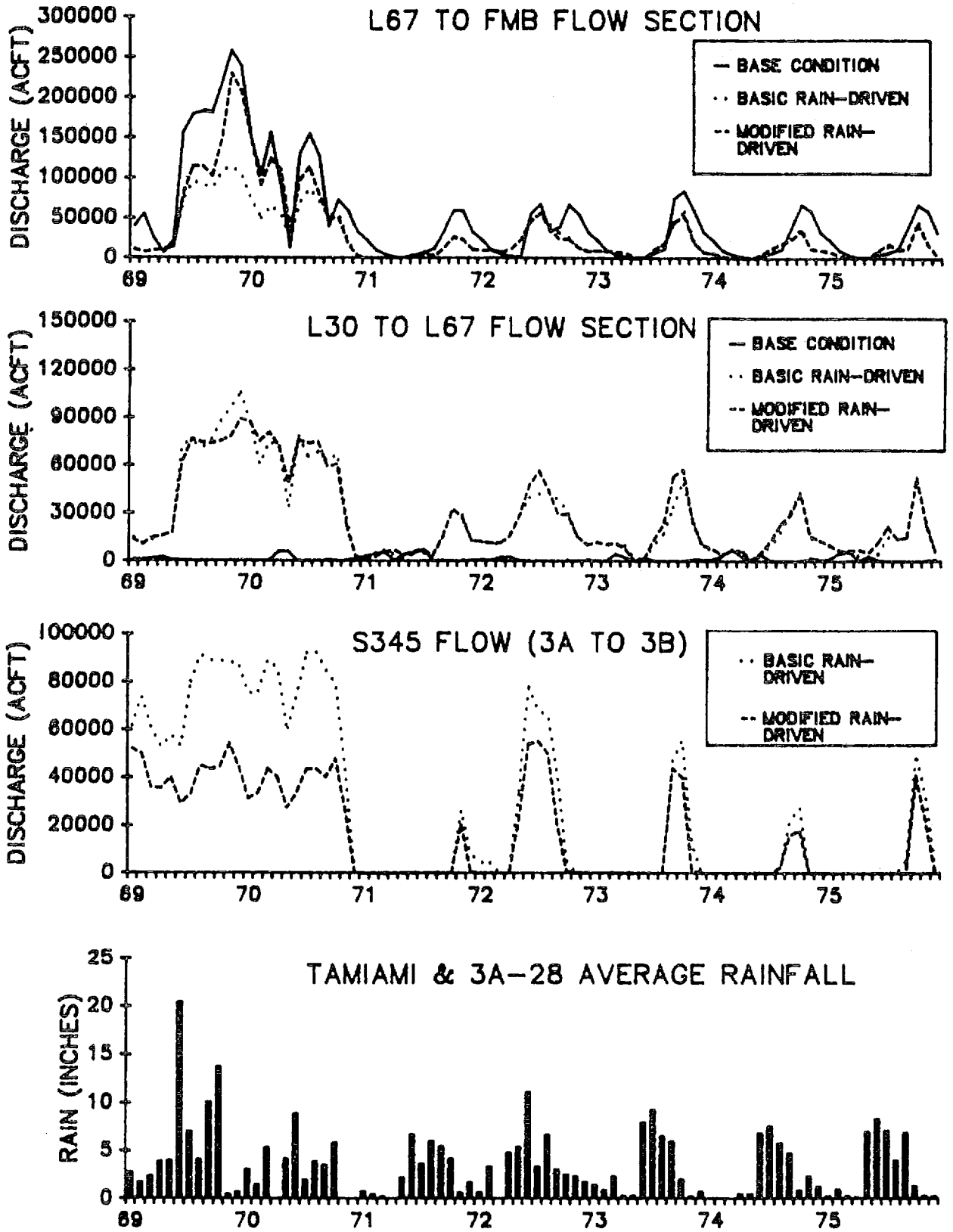

Figure 9. Monthly discharges into the western (L67 to FMB) and eastern (L30 to L67) Shark Slough flow sections and from WCA 3A into WCA 3B, related to average monthly rainfall, for the period from 1/1969 through 12/1975.

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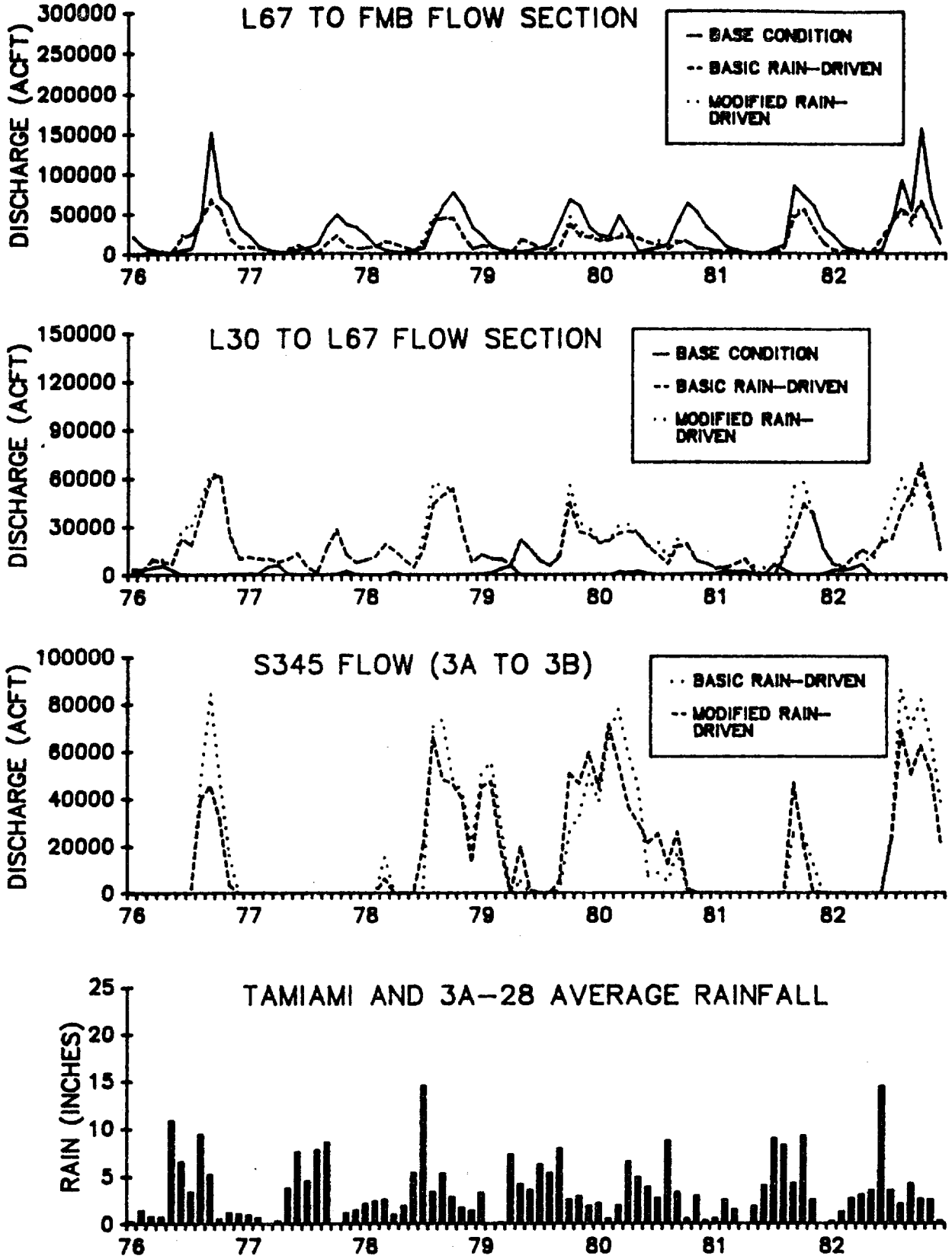

Figure 10. Monthly discharges into the western (L67 to FMB) and eastern (L30 to L67) Shark Slough flow sections and from WCA 3A into WCA 3B, related to average monthly rainfall, for the period from 1/1976 through 12/1982.

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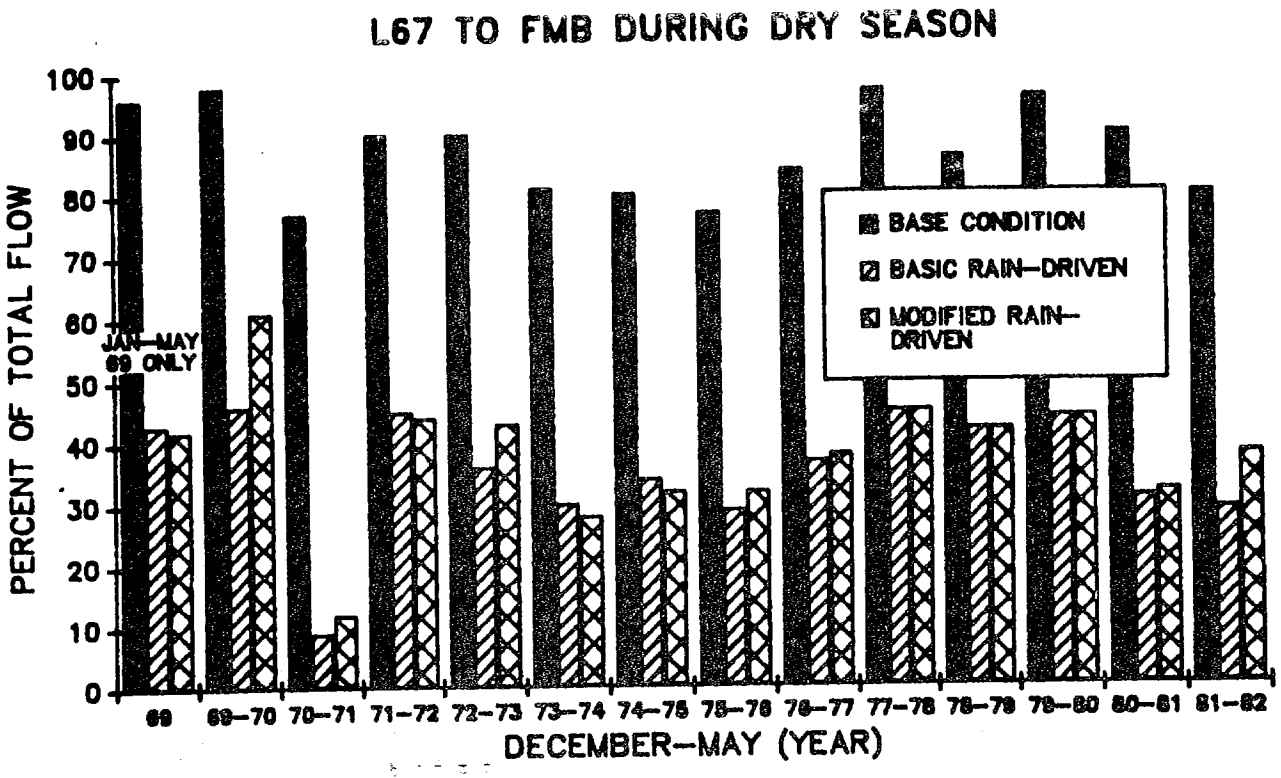
Restoration of Natural Flow Distributions

Historical flows into and through the Southern Everglades followed the natural topographic features of the area, with the bulk of these flows passing through the Tamiami Trail flow section in the present location of WCA 3B and Northeast Shark Slough (Wagner et al., in prep.). Since completion of the levees and canals around Water Conservation Areas 3A and 3B, and prior to the experimental delivery program, surface water flows had been confined to WCA 3A and the western portion of the Shark Slough (L-67 to 40 Mile Bend) flow section. This change caused overdrainage of the wetlands in WCA 3B and Northeast Shark Slough leading to resource degradation. Any plan for restoration of the Southern Everglades should include the return of surface water flows to this eastern flow-way, and efforts to return to pre-project flow distributions across Tamiami Trail.

Under the Minimum Delivery Schedule, as applied in the Base and Modified Base alternatives, all deliveries to Shark Slough are made through the western flow section (L67 to FMB). In addition, these alternatives do not include any new structures to move water from WCA 3A into WCA 3B. For these reasons the Base and Modified Base alternatives provide no flexibility to restore flows into the eastern flow-way, and no restoration of flows into Northeast Shark Slough. The Modified Base alternative does include the removal of the L-67 extension canal and levee, which does allow surface water to flow from the wetlands downstream of the S-12's eastward into Northeast Shark Slough. The impacts of these flows will be examined in a later section of this report.

The Basic Rain-Driven and Modified Rain-Driven alternatives both include water control structures (S-345's) to move surface water between WCA 3A and WCA 3B, providing additional flexibility to restore flows into WCA 3B. In addition, following the District's Rainfall-Driven Plan, 55 percent of each week's total flow is targeted to be delivered to the eastern Shark Slough flow section (L30 to L67) and the remaining 45 percent into the western flow section (L67 to FMB). Deliveries to Northeast Shark Slough under these two alternatives will be made through the S-355 structures. The establishment of deliveries from WCA 3A into WCA 3B, and subsequent deliveries from WCA 3B into Northeast Shark Slough, will produce a more natural flow-through system, and help to meet the request for restoration of the eastern flow-way.

Seasonal surface water flow percentages for the western Shark Slough flow section are shown in Figure 11 for the 14-year test period. Flow percentages under the Modified Base alternative are again not plotted because the distribution percentages are nearly identical to the Base alternative. In addition, Table 5 lists the flow percentages and basic descriptive statistics for all four of the proposed alternatives. Table 5 and the dry season plot in Figure 12 indicate that under the Base and Modified Base alternatives, approximately 88 percent of the December to May flows are delivered to Shark Slough through the western flow section. The remaining 12 percent of the total flow that passes into the eastern flow section is a result of high groundwater seepage rates through the southern levee system in WCA 3B, and/or losses into Northeast Shark Slough from dry season deliveries through the South Dade Conveyance System. In contrast, the Basic Rain-Driven and Modified Rain-Driven alternatives deliver only approximately 37 percent of the dry season flows through the western flow section. This indicates that the two rain-driven alternatives are much more successful at restoring pre-project dry season flow distributions than either the Base or Modified Base alternatives. During the wet season, the flow distributions under the Base and Modified Base alternatives are even worse, with approximately 99 percent of the June to November flows delivered through the western flow section. The Basic Rain-Driven and Modified Rain-Driven alternatives are again more successful at restoring pre-project flow distributions, with approximately 48 percent of the wet season flows through the western flow section.



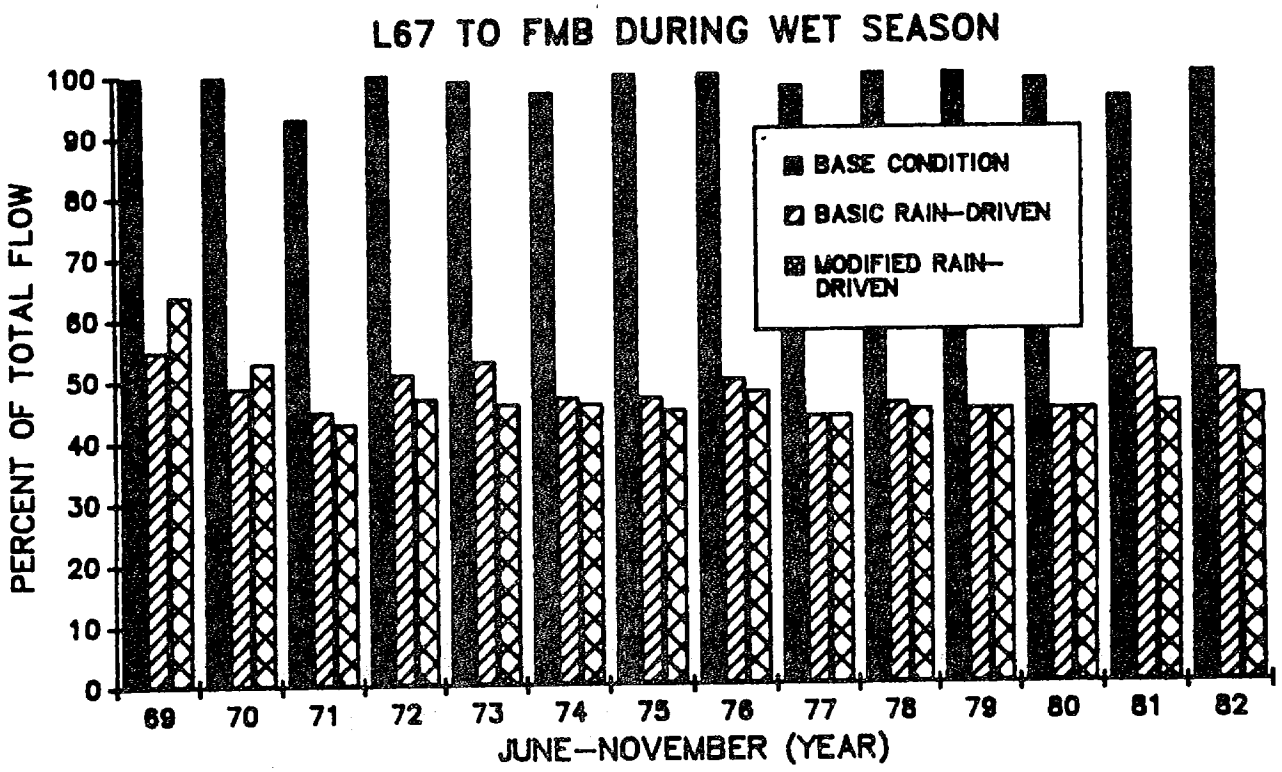


Figure 11. Seasonal flow percentages for the western Shark Slough flow section.

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Table 5. Seasonal flow percentages for the two Shark Slough flow sections (S12 - western flow section and NES - eastern flow section). (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	SEASON	BAS12%	BANES%	BCS12%	BCNES%	MUS12%	MUNES%	MPS12%	MPNES%
1969	DRY	95.5	4.5	96.1	3.9	42.7	57.3	42.3	57.7
1969	WET	100.0	0.0	100.0	0.0	54.3	45.7	64.3	35.7
1970	DRY	98.4	1.6	98.7	1.3	46.0	54.0	61.1	38.9
1970	WET	99.8	0.2	99.9	0.1	49.0	51.0	52.6	47.4
1971	DRY	77.1	22.9	79.9	20.1	9.4	90.6	11.8	88.2
1971	WET	93.0	7.0	93.8	6.2	44.9	55.1	43.9	56.1
1972	DRY	90.2	9.8	93.1	6.9	44.0	56.0	43.8	56.2
1972	WET	99.9	0.1	99.9	0.1	50.5	49.5	47.2	52.8
1973	DRY	89.9	10.1	91.7	8.3	36.1	63.9	43.1	56.9
1973	WET	98.7	1.3	99.0	1.0	52.9	47.1	46.1	53.9
1974	DRY	81.1	18.9	81.9	18.1	29.7	70.3	28.4	71.6
1974	WET	96.7	3.3	97.3	2.7	47.0	53.0	45.6	54.4
1975	DRY	79.9	20.1	80.9	19.1	34.2	65.8	31.7	68.3
1975	WET	99.5	0.5	99.5	0.5	47.3	52.7	45.2	54.8
1976	DRY	77.2	22.8	79.5	20.5	29.2	70.8	32.3	67.7
1976	WET	99.8	0.2	99.8	0.2	50.3	49.7	47.8	52.2
1977	DRY	83.7	16.3	84.2	15.8	36.6	63.4	37.8	62.2
1977	WET	98.0	2.0	98.6	1.4	44.5	55.5	44.3	55.7
1978	DRY	96.9	3.1	98.6	1.4	44.7	55.3	44.6	55.4
1978	WET	99.9	0.1	100.0	0.0	46.4	53.6	45.2	54.8
1979	DRY	85.5	14.5	86.8	13.2	41.6	58.4	41.9	58.1
1979	WET	99.9	0.1	99.9	0.1	44.9	55.1	45.0	55.0
1980	DRY	96.0	4.0	98.6	1.4	44.3	55.7	44.1	55.9
1980	WET	99.0	1.0	99.2	0.8	44.5	55.5	44.6	55.4
1981	DRY	89.8	10.2	92.9	7.1	30.5	69.5	32.4	67.6
1981	WET	96.2	3.8	96.0	4.0	54.2	45.8	46.1	53.9
1982	DRY	80.3	19.7	83.9	16.1	28.5	71.5	37.9	62.1
1982	WET	99.9	0.1	99.9	0.1	51.3	48.7	47.4	52.6
DRY MEAN		87.3	12.8	89.1	10.9	35.5	64.5	38.1	61.9
DRY ST. DEV.		7.6	7.6	7.4	7.4	9.9	9.9	11.1	11.1
WET MEAN		98.6	1.4	98.8	1.2	48.7	51.3	47.5	52.5
WET ST. DEV.		2.0	2.0	1.9	1.9	3.6	3.6	5.3	5.3

Examination of monthly flow distribution percentages for the two rain-driven alternatives indicates that both alternatives frequently missed the target 45/55 split defined in the District's Rainfall-Driven Plan. These periods when flows through the western flow section exceed 45 percent occurred during the peak of the wet season and generally lasted for one to three months. The only extended period when these alternatives failed to meet the defined 45 percent western flow section target occurred in the wet season of 1969 and early dry season of 1970. This period contained the largest flows on record for the 14-year test period. This characteristic of not meeting the flow distribution percentages established under the Rainfall-Driven Plan points to a limitation of the maximum flow capacity that the new S-355 structures can convey into Northeast Shark Slough. This limitation may have detrimental wildlife impacts on the downstream areas of western Shark Slough if these high flow periods occur during the early dry season.

Mitigation of Large Regulatory Releases

Under natural, unmanaged conditions, the impacts of large rainfall events were attenuated by the slower surface water flow rates through the open marshes. With the current system of upstream canals, levees, and water conservation areas, stormwater is moved rapidly through the system. Current discharges to Shark Slough must now respond to supplemental releases in excess of local rainfall, which are made whenever stages in the upstream water conservation areas exceed their regulation schedules.

Under the Base and Modified Base alternatives, flows to the park followed the Minimum Delivery Schedule until the WCA 3A regulation schedule was exceeded. Once this happened the S-12 structures were opened full until water levels in WCA 3A dropped back below the schedule. In addition, all of the flows to Shark Slough were required to pass through the western flow section. This strict adherence to the old regulation schedule and inability to divert excess flows into adjacent areas, produced abrupt increases in deliveries to Shark Slough (see Figures 10 and 11).

Under the Basic Rain-Driven and Modified Rain-Driven alternatives, flows to the park are controlled by upstream rainfall until water levels in WCA 3A enter a series of transition zones defined by the District's Rainfall-Driven Plan. Once into a transition zone, regulatory discharges increase at a rate of 2500 cfs for each foot increase in stage above the base of the transition zone. In addition, flows through the study area were delivered from WCA 3A directly into WCA 3B and then into Northeast Shark Slough. The implementation of these transition zones and the spreading of flows over a larger area, produced a more gradual rise in the Shark Slough discharge hydrographs and extended the recession periods after peak discharges (see Figures 10 and 11). For these reasons the two rain-driven alternatives mitigated the effects of disruptive regulatory releases by lowering peak flows, spreading flows over a longer time period, and passing excess water into WCA 3B.

Figure 12 illustrates how much more effective the two rain-driven alternatives were at mitigating large regulatory releases to the Shark Slough Basin. The period from June of 1969 through August 1970 had the highest overall flows during the test period and the largest regulatory discharges. Under the Base and Modified Base alternatives, discharges to the western Shark Slough flow section remained above 100,000 acre-feet for 13 of the 15 months. Flows were in excess of 150,000 acre-feet for nine of these months, and in excess of 200,000 acre-feet for three months during this period. Large discharge events of this type are very damaging to downstream wildlife, particularly when they occur during the dry season.

Under the Basic Rain-Driven alternative, discharges to the western Shark Slough flow section exceeded 100,000 acre-feet for only three months. In contrast, the Modified Rain-Driven alternative had discharges through the western flow section in excess of 100,000 acre-feet for ten months, and flow exceeded 200,000 acre-feet during two months. This indicates that both of the rain-driven alternatives were effective at mitigating damaging flows into Shark Slough, but the Basic Rain-Driven alternative was significantly more effective. This large difference in effectiveness between these two alternatives was the result of the volumes of stormwater that were diverted from WCA 3A into WCA 3B. The closure of the S-349 structures, under the Basic Rain-Driven alternative, apparently allowed an additional 490,000 acre-feet of surface water to be diverted into WCA 3B.

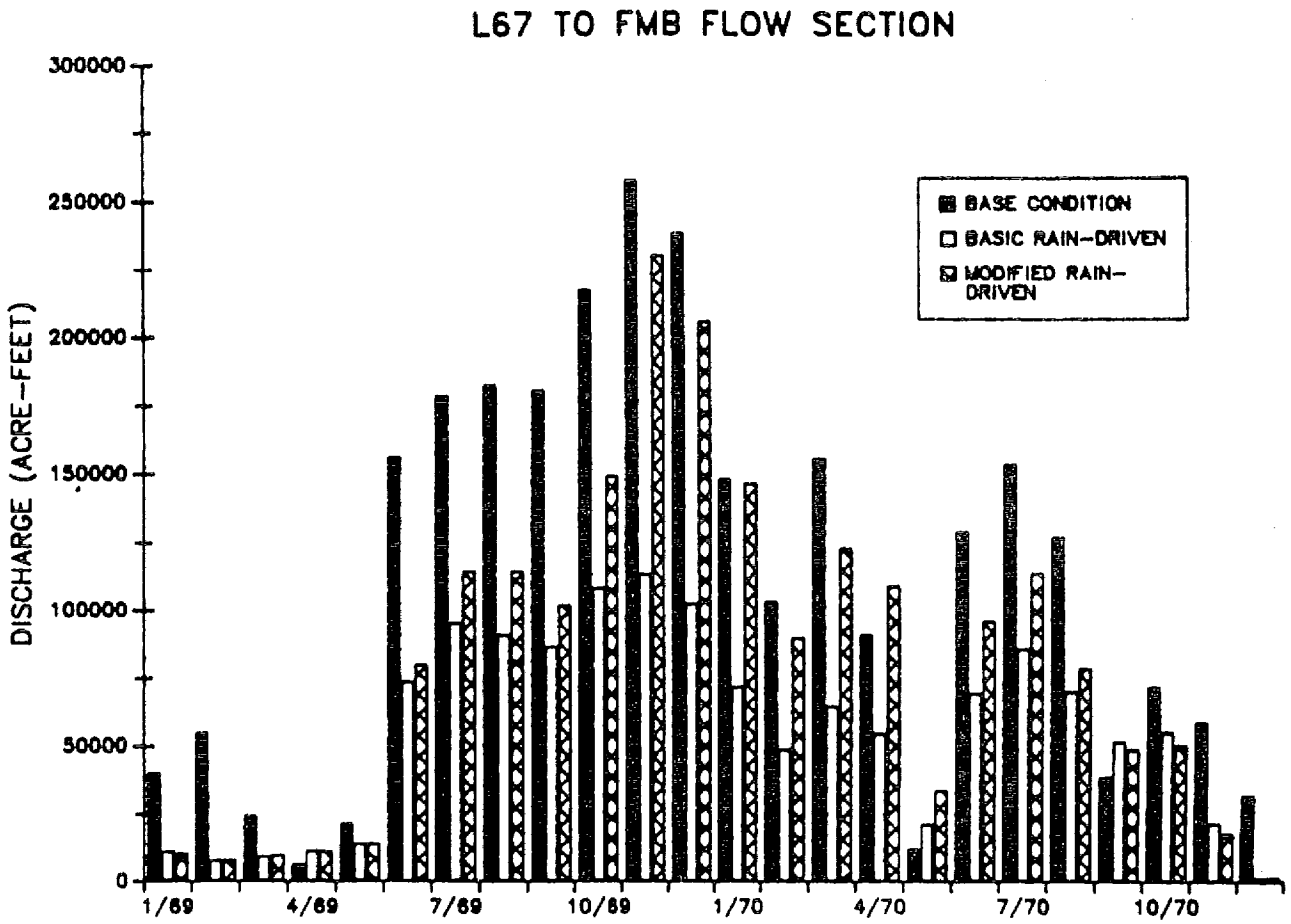

Figure 12. Monthly discharges through the western Shark Slough flow section between January 1969 and December 1970.

Restoration of Surface Water Depths and Hydroperiods

Under natural, unmanaged conditions, surface water in the Southern Everglades would occur first in the lower-lying areas of the central sloughs and expand into higher elevated marshes throughout the wet season. With the current system of canals, levees, and surface water impoundments, much of this natural pattern of surface water depths and hydroperiods has been altered. Scientists studying the lower Everglades have long recognized that the marshes in the Water Conservation Areas have been altered by overdrainage in the northern areas and excessive ponding behind the levees of the southern ends (SFWMD 1989).

Similarly, the closure of WCA 3A and WCA 3B in 1962 eliminated the natural pool of surface water that formed each year in the low-lying areas of WCA 3B and Northeast Shark Slough. This disruption of the natural flow pattern caused overdrainage of Northeast Shark Slough and a reduction in surface water flows into the southern portion of Shark Slough and its downstream estuaries. For these reasons, a major goal of our restoration effort is directed at the restoration of flows into this eastern flow-way through WCA 3B and into Northeast Shark Slough.

Surface Water Characteristics for the Four Alternatives

Estimated water depth distribution maps for each of the alternatives were compared to the soils and elevation information displayed in Figure 7, and to a series of water depth maps generated from the natural system simulation model run, to evaluate how well they met the objectives of restoring more natural water depth and hydroperiod patterns within the study area. This analysis was done primarily by examining the seasonal and annual variation in water depths and hydroperiods in each of the four sub-basins (see Fig. 1).

A series of tables were produced that showed the average percentage of each basin that was inundated in four water depth classes for the wet season (June through November) and dry season (December through May) of each year, as well as overall statistics for the 14-year test period. The water depth classes were defined using the following criteria:

1. Dry - The percentage of the area with no surface water (water surface below the ground).

2. Transitional - The percentage of the area with surface water from 0.0 to 0.5 feet deep.

3. Shallow - The percentage of the area with surface water from 0.5 to 1.0 feet deep.

4. Deep - The percentage of the area with surface water in excess of 1.0 feet deep.

A similar series of tables were produced for corresponding surface water hydroperiod data in five hydroperiod classes for the four sub-basins for each hydrologic year (June through May) and the overall statistics for the 14-year test period. The hydroperiod classes were defined using the following criteria:

1. Category 0 - The percentage of the area with inundations lasting less than one month.

2. Category 1-3 - The percentage of the area with inundations from 1 to 3 months.

3. Category 4-6 - The percentage of the area with inundations from 4 to 6 months.

4. Category 7-9 - The percentage of the area with inundations from 7 to 9 months.

5. Category 10-12 - The percentage of the area with inundations from 10 to 12 months.

Two key grid cells in each of the four study basins were selected for more detailed analyses, and surface water hydrographs were generated based on the average end of month water levels from the four alternatives. These hydrographs are useful as a graphical method of comparing the impacts of the proposed alternatives in selected areas of the four study basins. These selected grid cells contained actual water level recording stations. For this reason they will be referred to throughout the remainder of this report by their station names. Figure 13 shows the location of each of these stations (grid cells) within the study area. After reviewing the seasonal water depth, annual hydroperiod, and seasonal flow data, a series of water depth and hydroperiod maps were then generated for three years selected to represent expected surface water conditions under dry, normal, and wet climatic conditions. These maps were then used to examine any differences in the spatial patterns of these variables under the four proposed alternatives within each study basin.

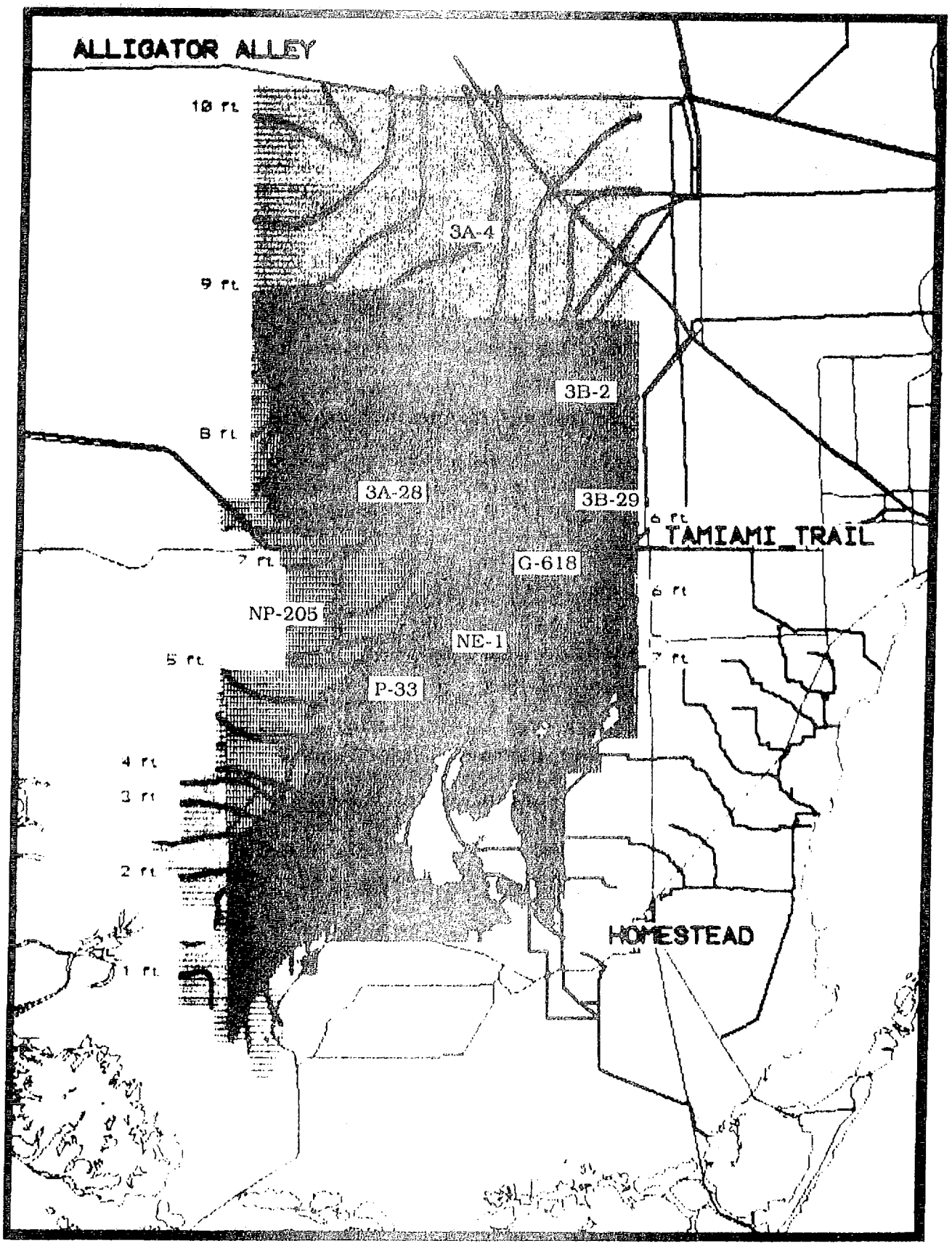

Figure 13. Soils and elevation map of the study area showing the location of the selected grid cells for detailed water depth analyses.

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Surface Water Depths in Northeast Shark Slough

Hydrographs for the two selected stations within the Northeast Shark Slough Basin (G-618 and NE-1) are shown in Figure 14. The hydrograph for station G-618 indicates that in the northern portion of the basin, average water levels increased from 0.25 to 0.69 feet during the wet season (June through November) under the Modified Base alternative, and increased from 0.33 to 0.95 feet during the dry season (December through May), when compared to Base conditions. This lengthened the average hydroperiod by approximately two months. Average water level increases were even higher under the two rain-driven alternatives. During the wet season average water level increases ranged from 0.65 to 1.08 feet under the Basic Rain-Driven alternative, and from 0.94 to 1.22 feet under the Modified Rain-Driven alternative. Dry season average water level increases ranged from 0.72 to 1.12 feet and from 0.86 to 1.27 feet for the Basic and Modified Rain-Driven alternatives, respectively. These higher water levels lengthened the average hydroperiod by three months, and produced extended periods of continuous inundation.

The hydrograph for station NE-1 indicates that in the central slough flow-way, average wet season water levels increased by a maximum of 0.59, 0.86, and 0.96 feet under the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives, respectively. Similar dry season water level increases ranged from a maximum of 0.80, 0.69, and 0.85 feet, respectively. These water level increases lengthened average hydroperiods by two months under the Modified Base and Basic Rain-Driven alternatives, and by three months under the Modified Rain-Driven Alternative. The Modified Rain-Driven alternative was the only alternative that created sufficient water level increases to re-establish average 12 month hydroperiods within this deeper, central slough habitat.

Table 1 in Appendix A summarizes the seasonal water depth characteristics throughout the Northeast Shark Slough Basin. The table indicates that the Modified Rain-Driven alternative was the most successful of the alternatives at restoring deep water conditions in NESS, with an average 29 percent increase in the percentage of the basin in the deep water depth class during the wet season. This alternative also maintained the largest average area of remaining surface water during the dry season. These water depth increases were the result of large regulatory flows into NESS in response to the higher stages maintained in WCA 3A under this alternative. Note that under all of the alternatives, at least 50 percent of the Northeast Shark Slough Basin would dry out on average each year (see summary statistics in Table 1, Appendix A).

Figure 15 shows the estimated water depth distributions for the four proposed alternatives at the end of October for the selected normal year (1976-77). The maps indicate that the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives were all somewhat effective at restoring deep water conditions along the eastern flow-way, but that only the two rain-driven alternatives re-established a continuous pool of deep water throughout the entire length of the flow-way from WCA 3B into the headwaters of Shark Slough. Also note that none of the alternatives re-inundated the shorter hydroperiod marshes in the Rocky Glades under average wet season conditions.

Figure 16 shows the estimated water depth distributions for the four alternatives at the end of April for the selected normal year (1976-77). The maps indicate that none of the alternatives are effective at maintaining surface water in the eastern flow-way under these conditions. The two rain-driven alternatives did produce the largest area of remaining surface water at the end of this year. Under below normal wet season conditions the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed an increase in water depths over the Base alternative (see periods such as June through November 1974 in Table 1, appendix A). The Modified Rain-Driven alternative was again the most successful at maintaining wet season water depths during below normal rainfall periods. Figure 17 shows the estimated water depth

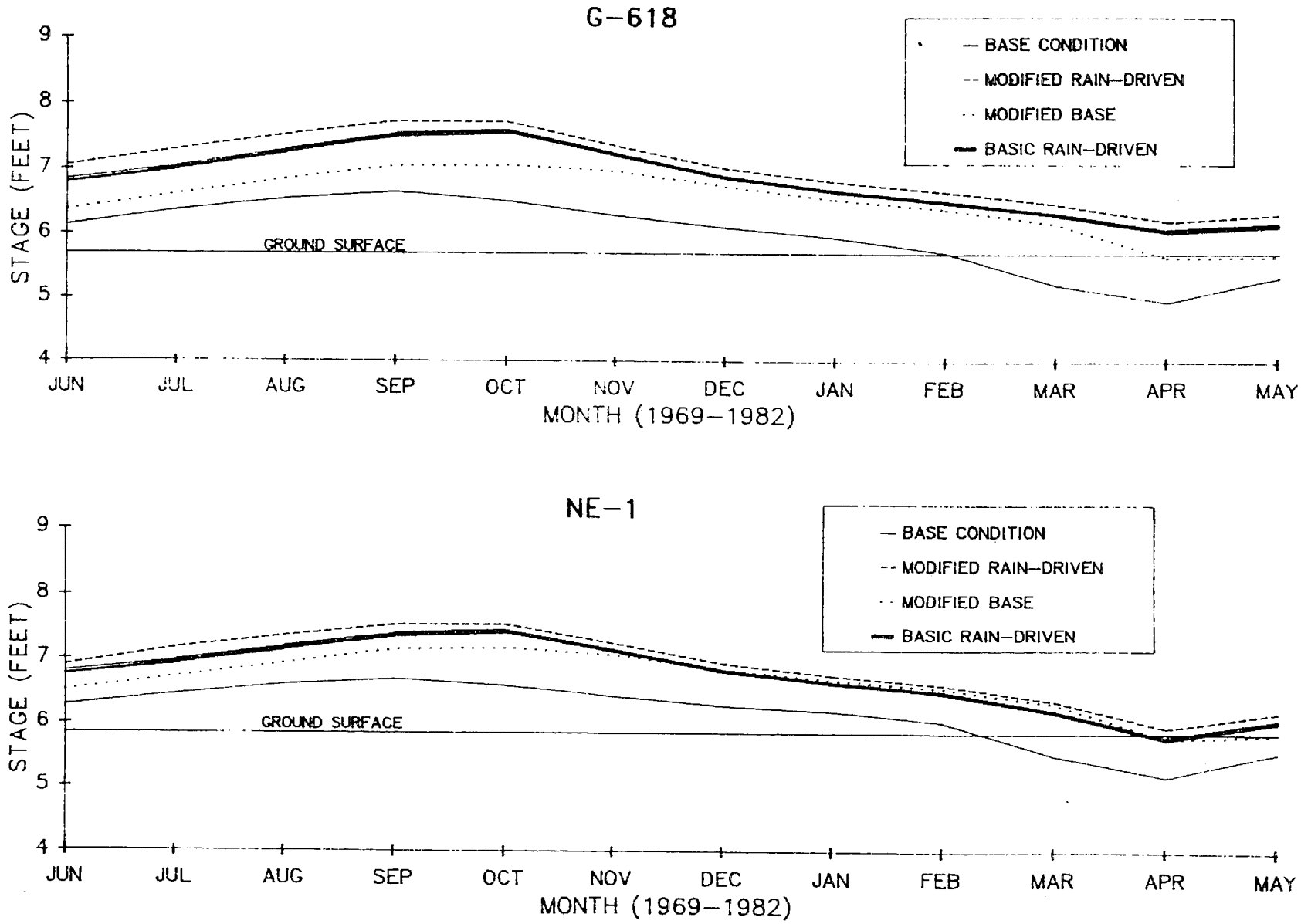

Figure 14. Surface water hydrographs for stations G-618 and NE-1 in the Northeast Shark Slough Basin.

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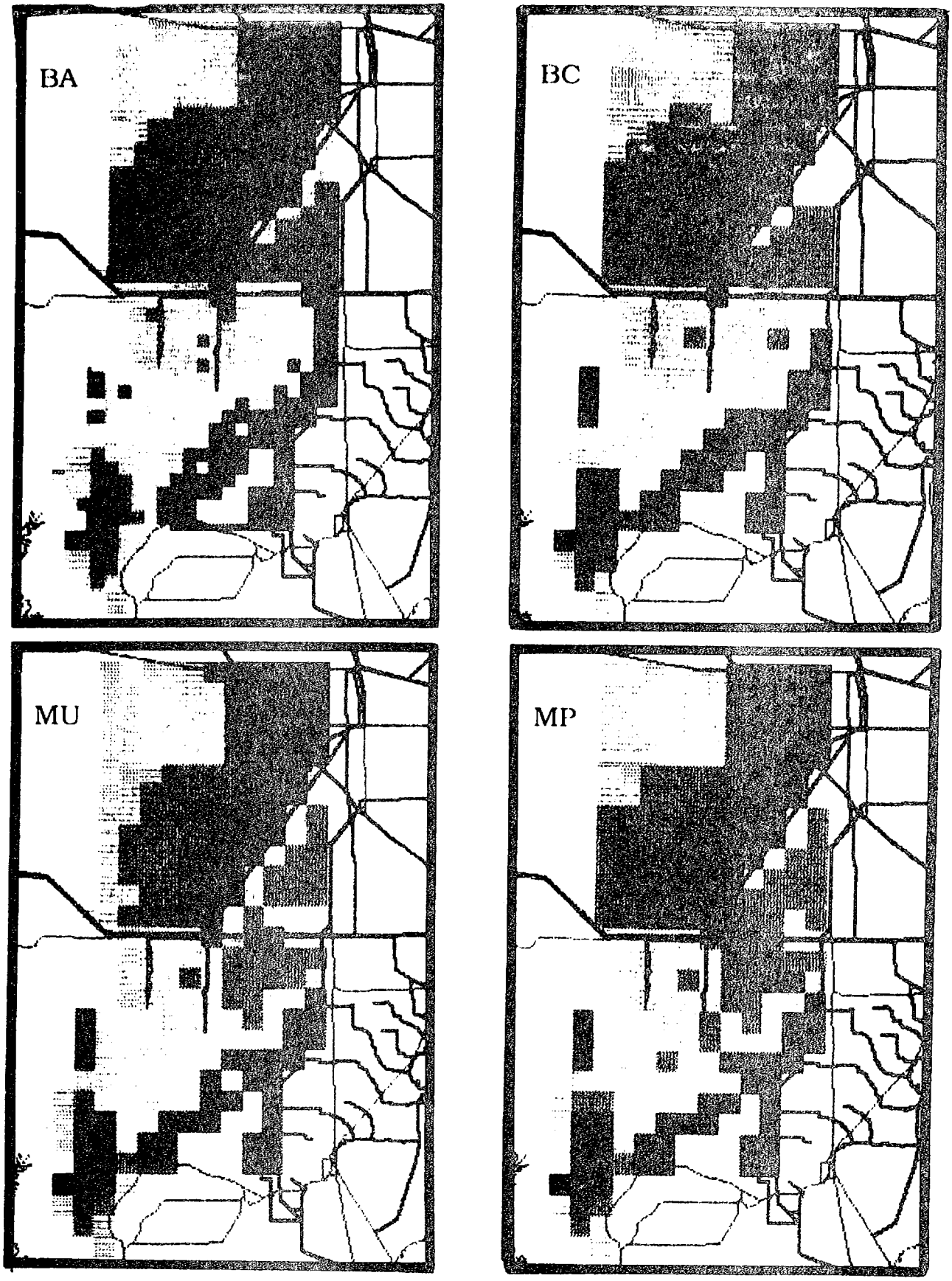

Figure 15. Surface water distribution map for October 1976. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

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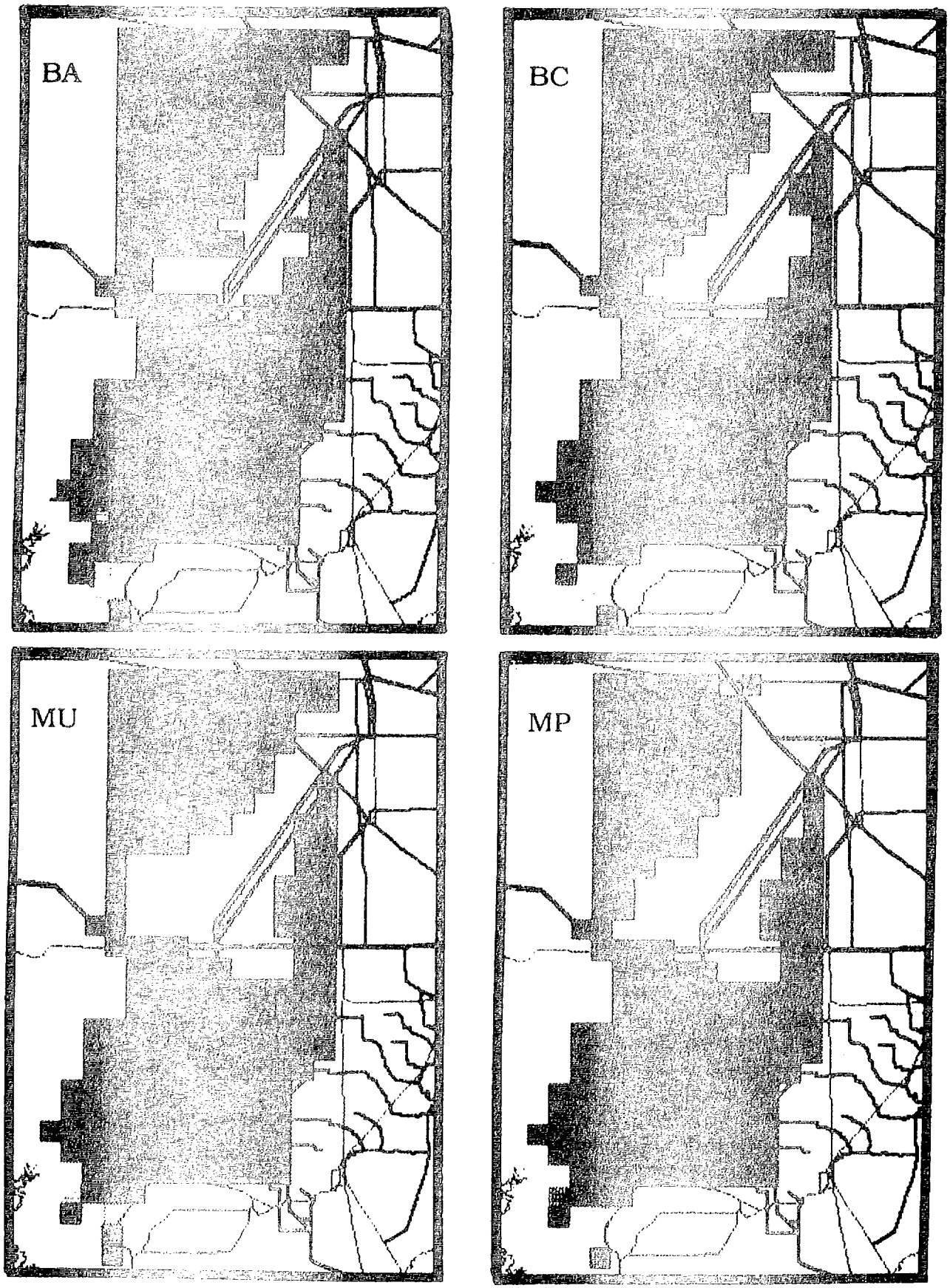

Figure 16. Surface water distribution map for April 1977. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

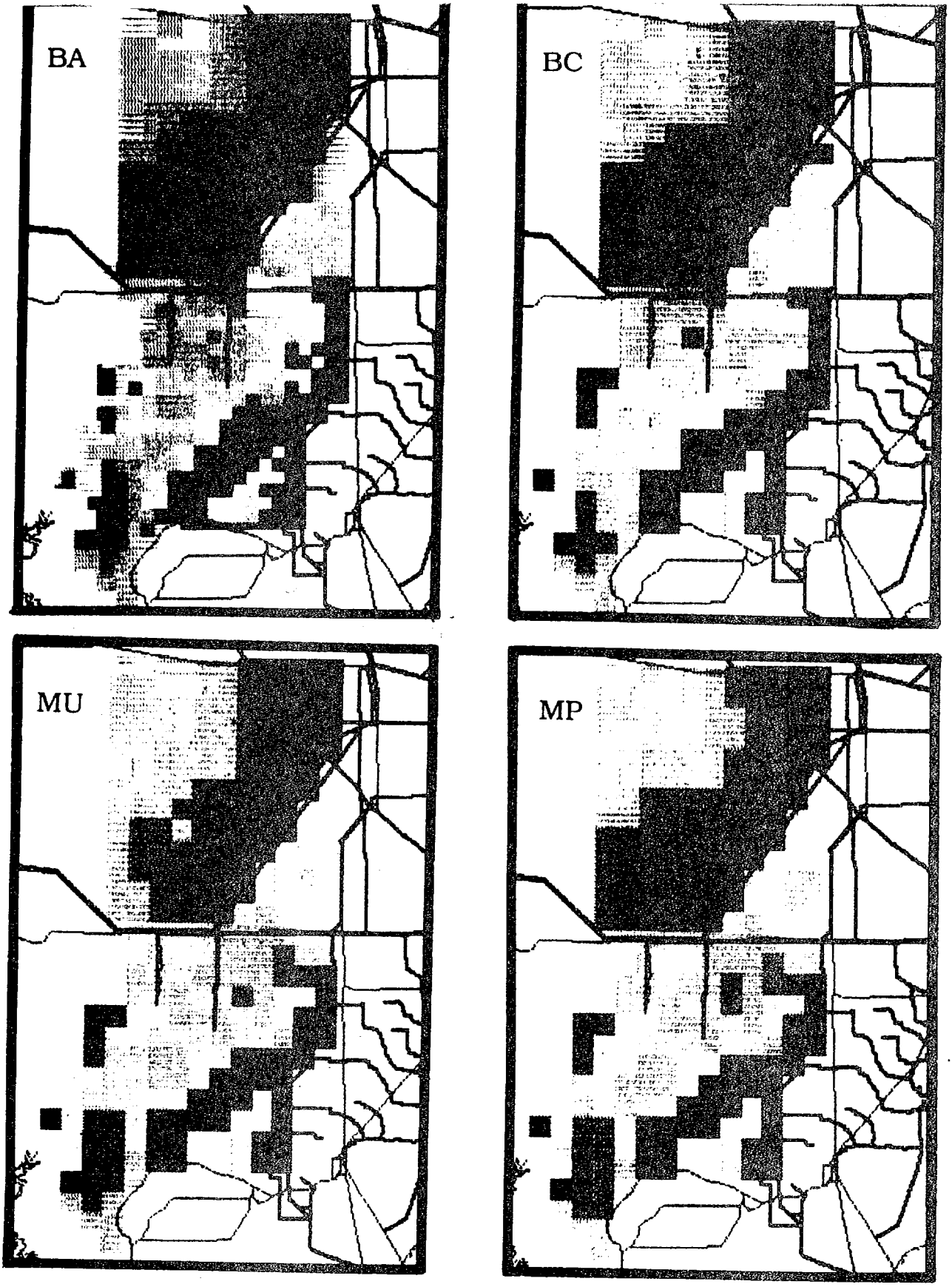

Figure 17. Surface water distribution map for October 1974. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

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distributions at the end of October for this selected dry year (1974-75). The maps indicate that the two rain-driven alternatives are equally successful at maintaining a deep water pool in NESS during a dry year, and that the Modified Base alternative produced a much smaller pool.

Figure 18 shows the expected water depths at the end of April for the selected dry year (1974-75). The maps indicate than none of the alternatives maintained any surface water within Northeast Shark Slough under these conditions. The Modified Base and Modified Rain-Driven alternatives produced substantial reductions in the percentage of the basin that experienced a complete drydown (see Table 1, appendix A). The Basic Rain-Driven alternative was slightly less effective at reducing these drydowns.

Figure 19 shows the estimated water depth distributions at the end of October during the selected wet year (1969-70). Under these high wet season rainfall conditions the majority of the Northeast Shark Slough Basin would be covered by deep water under all of the alternatives. The Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives all showed nearly identical water depth conditions. Figure 20 shows that by the end of the 1970 dry season, the amount of deep water in NESS was reduced to 20 percent under the Base alternative, while the majority of this deep water remained in NESS under the other three alternatives.

Hydroperiods in Northeast Shark Slough

The annual hydroperiod data for the four proposed alternatives throughout all 14 years is summarized in Table 2, Appendix A. The table suggests that for the selected normal hydrologic year (June 1976 through May 1977), the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives were equally successful at increasing hydroperiods in Northeast Shark Slough. Figure 21 and the raw hydroperiod data for 1976-77 year shows that this was not the case, and indicate that neither the Base nor the Modified Base alternatives produced areas within NESS that had a 12 month hydroperiod. In contrast, the two rain-driven alternatives had approximately 9 percent of the basin with a 12 month hydroperiod. Of these two alternatives, the Modified Rain-driven alternative produced a slightly higher percentage of the area in longer hydroperiods, again in response to higher regulatory flows into NESS under this alternative.

During the selected dry year (June 1974 through May 1975) none of the alternatives produced areas within Northeast Shark Slough with 12 month hydroperiods (see Fig. 22). The Basic Rain-Driven alternative produced the greatest increase in the percentage of the area with 7 to 9 month hydroperiods (11 percent). In contrast, the Modified Base alternative produced the greatest increase in the percentage of the area with 10 to 12 month hydroperiods (see Table 2, Appendix A).

Under very wet conditions (such as in the June 1969 through May 1970 period) the hydroperiod maps indicate that very similar patterns occurred under the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives within Northeast Shark Slough. Only the Base alternative showed a significant reduction of hydroperiods in NESS, suggesting that excessive drainage would occur under this alternative even during very wet years (see Fig. 23).

Surface Water Depths in Western and Central Shark Slough

Hydrographs for the two stations in western Shark Slough (P-33 and NP-205) are shown in Figure 24. The hydrograph for station P-33 indicates that in the central flow-way of the slough, the Modified Base alternative would lower average water levels by 0.07 to 0.19 feet throughout the year, compared to the Base alternative. Under the Basic Rain-Driven

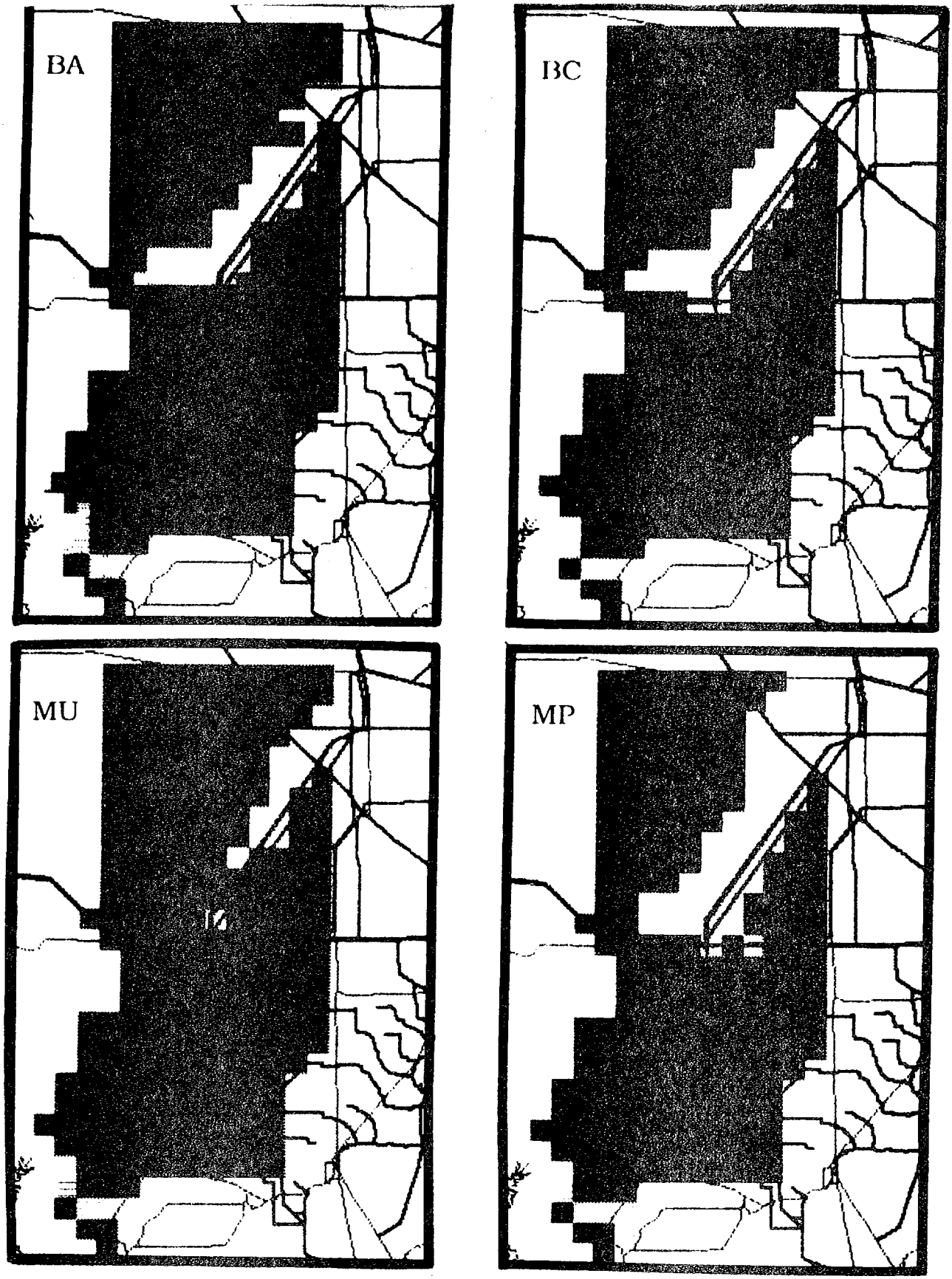

Figure 18. Surface water distribution map for April 1975. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

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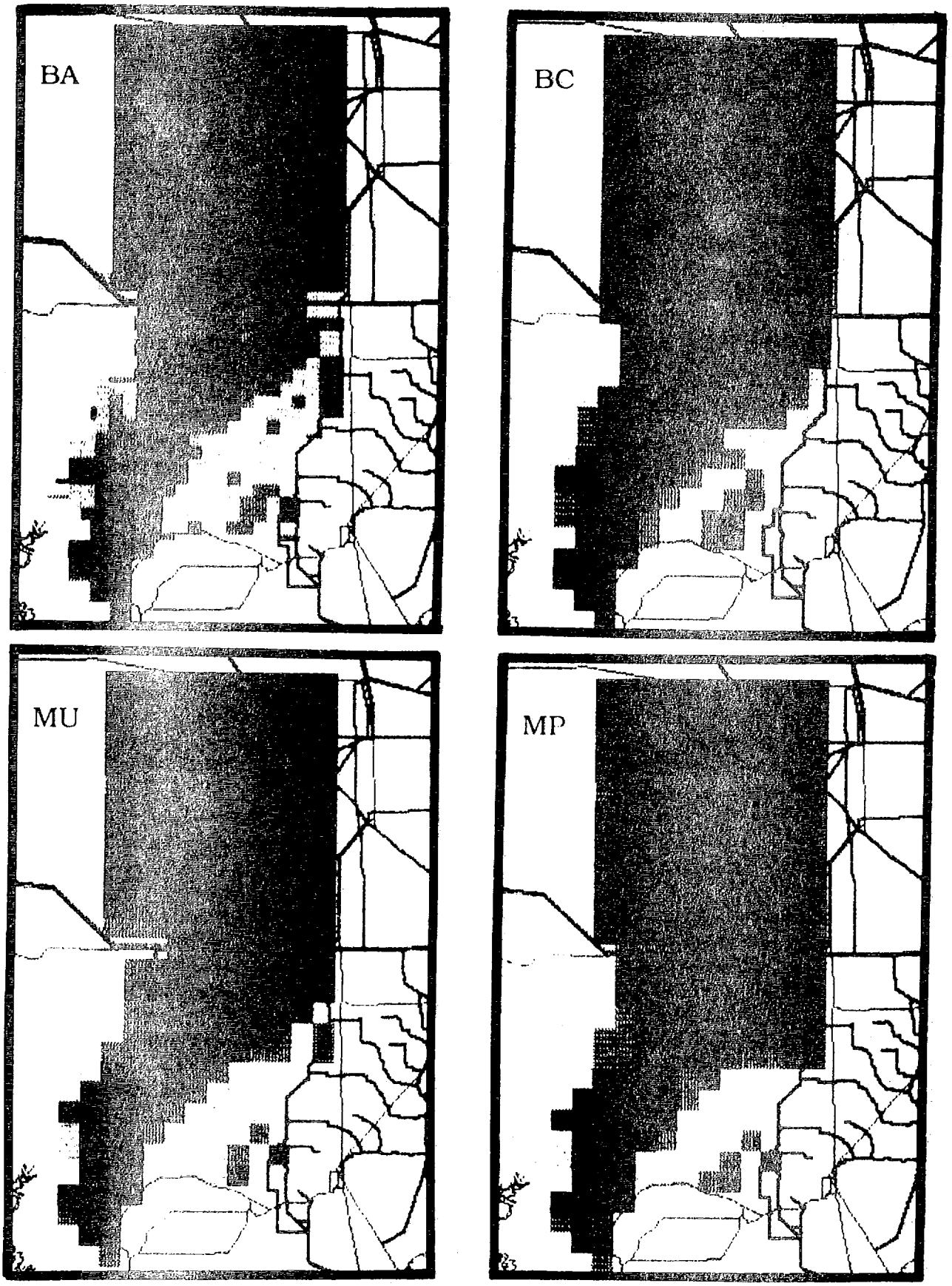

Figure 19. Surface water distribution map for October 1969. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

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Figure 20. Surface water distribution map for April 1970. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 2 for the water depth classes used in this analysis.

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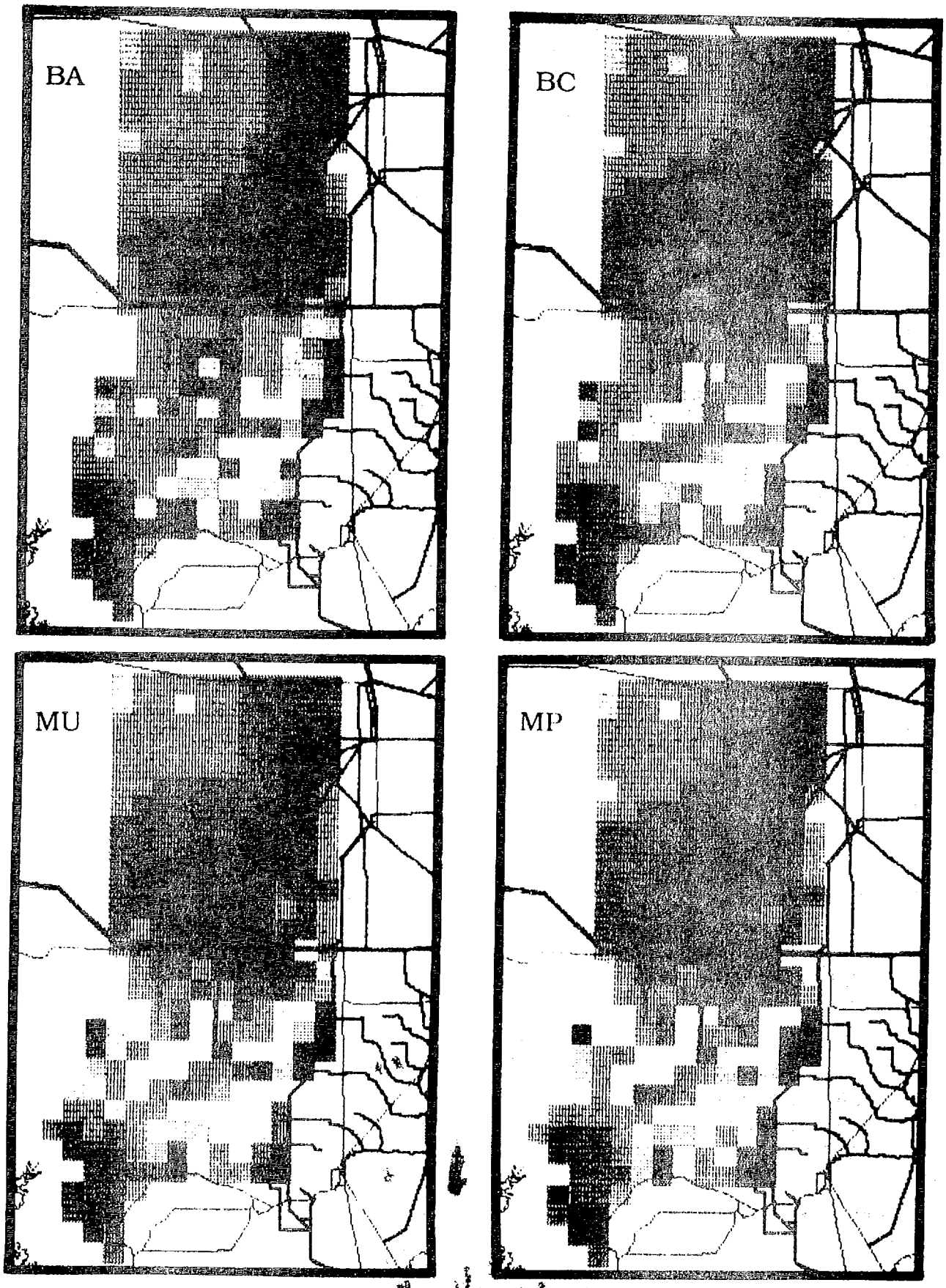

Figure 21. Surface water hydroperiod map for June 1976 through May 1977. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 3 for the water depth classes used in this analysis.

Figure 22. Surface water hydroperiod map for June 1974 through May 1975. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 3 for the water depth classes used in this analysis.

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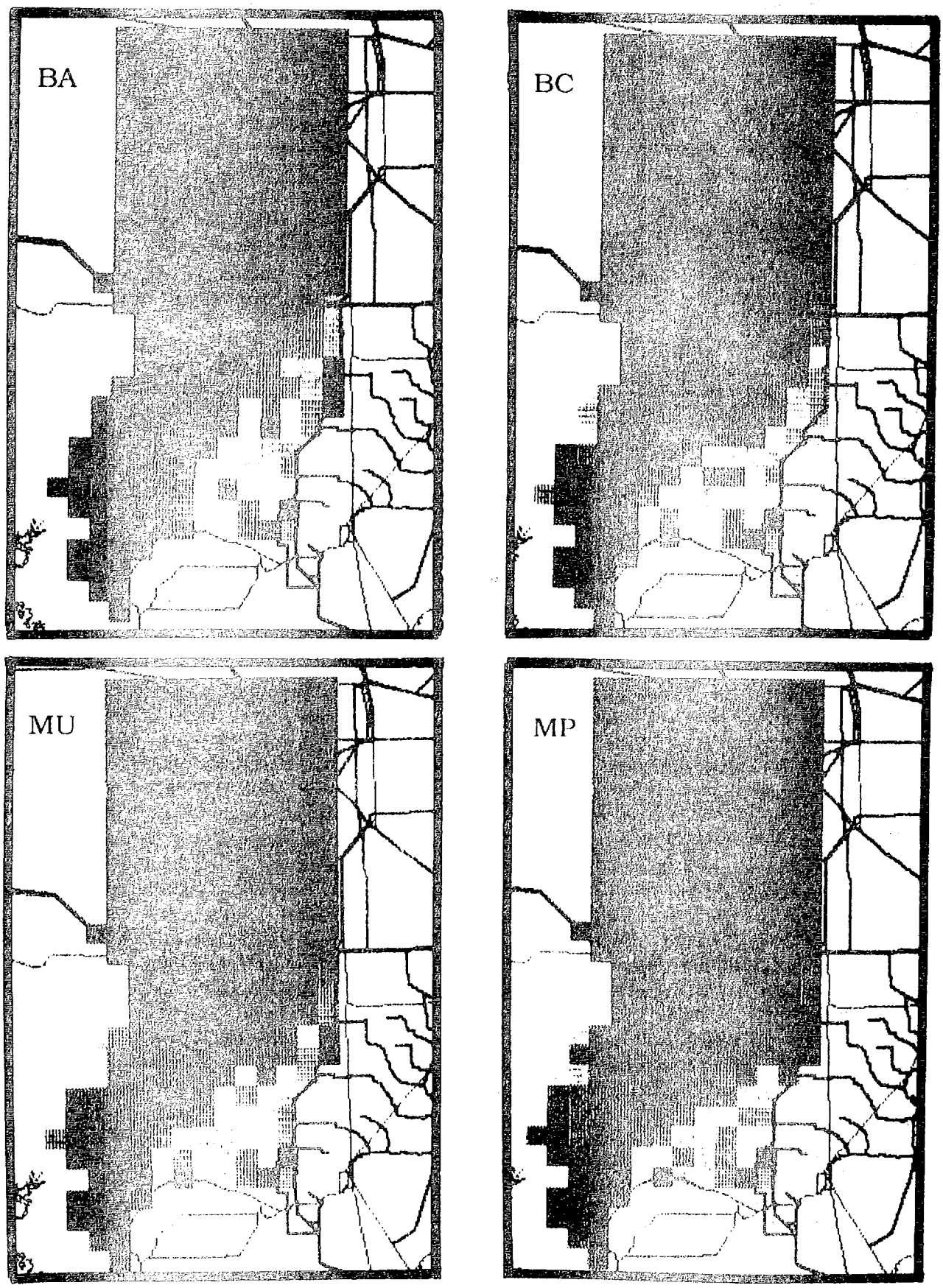

Figure 23. Surface water hydroperiod map for June 1969 through May 1970. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP). See Table 3 for the water depth classes used in this analysis.

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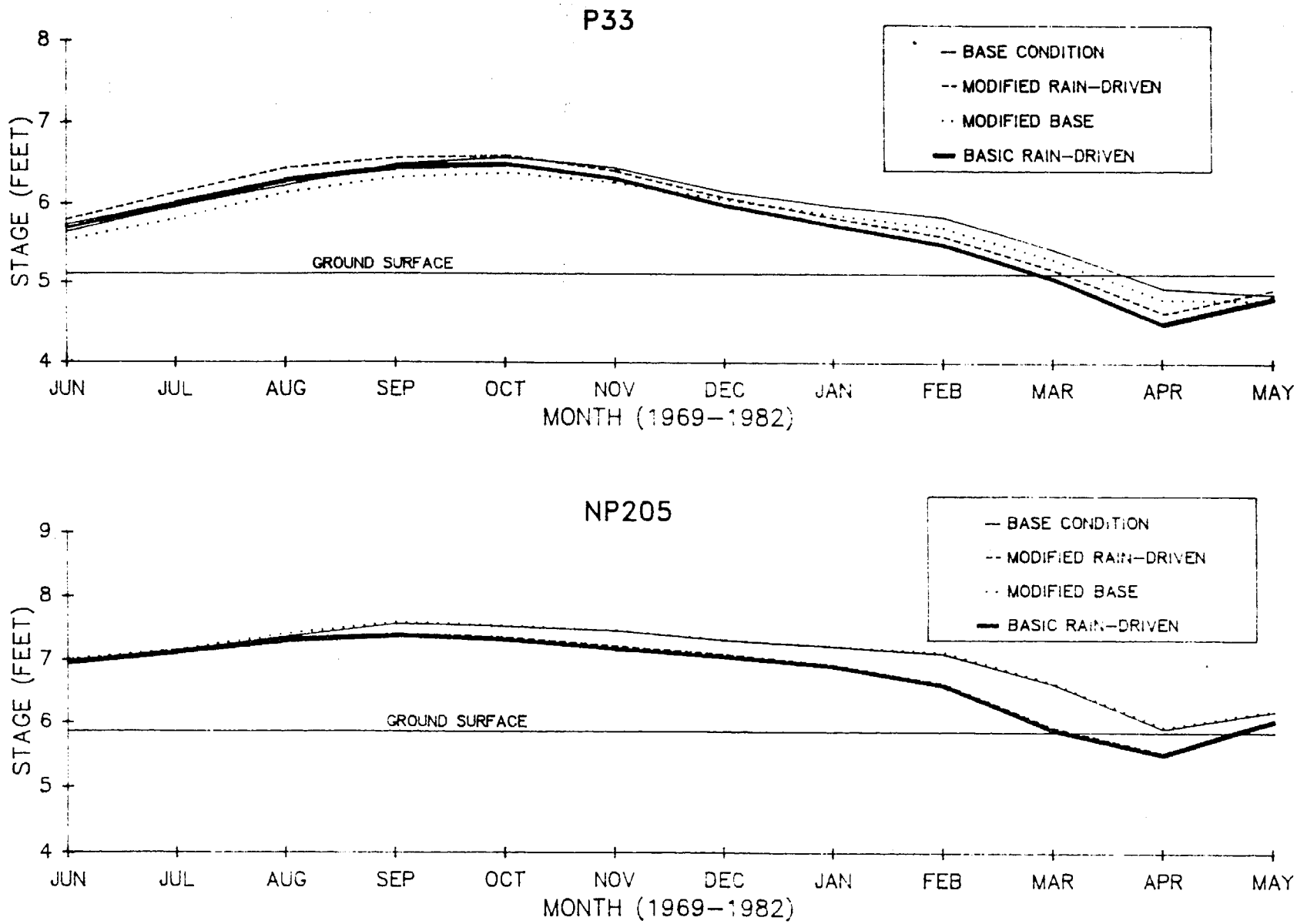

Figure 24. Surface water hydrographs for stations P-33 and NP-205 in the western Shark Slough basin.

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alternative, average water levels are from 0.04 to 0.44 feet lower between September and May, but are slightly higher during June through August. The Modified Rain-Driven alternative shows a similar trend with average water level reductions of 0.04 to 0.31 between November through May, and increases of up to 0.22 feet between June through October. All of these water level reductions were expected, and are the result of removal of the L-67 extension levee and, for the two rain-driven alternatives, water deliveries shifted into Northeast Shark Slough to maintain the 45/55 percentage established in the District's Rainfall-Driven Plan. Note that these water level reductions shortened the average annual hydroperiod at P-33 by less than one month.

The hydrograph for station NP-205 in extreme western Shark Slough shows that there would be essentially no change in average water levels under the Modified Base alternative. Under the two rain-driven alternatives average wet season water levels would drop by 0.02 to 0.23 feet, and decreases of 0.14 to 0.73 feet would occur during the dry season. These reductions occurred in response to the diversion of flows away from western Shark Slough. These relatively large dry season water level reductions shortened the average annual hydroperiod by approximately one month, under the two rain-driven alternatives.

Table 3 in Appendix A summarizes the seasonal water depth characteristics throughout the western Shark Slough Basin. Under average conditions both the wet season and dry season water depth characteristics for the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed only slight changes when compared to the Base alternative. In general, the Modified Rain-Driven alternative maintained the highest average percentage of the basin in deep water, while the Basic Rain-Driven alternative caused a slight increase in the average percentage of the basin experiencing a complete drydown.

The estimated wet season water depth distribution maps for the selected normal year (Fig. 15) indicate that the two rain-driven alternatives are much more effective at maintaining a central core of deep water along the eastern flow-way from Northeast Shark Slough into the downstream estuaries under normal wet season hydrologic conditions. In contrast, the Base and Modified Base alternatives produced nearly equal percentages of deep water, but these areas occurred in more isolated pools. Under average dry season conditions the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed an overall decrease in water depths over the Base alternative (see summary statistics in Table 3, Appendix A). Figure 16 shows that by the end of the dry season during the selected normal year none of the alternatives maintained surface water in the basin.

Under below normal wet season conditions the estimated water depth distribution maps indicate that the Base and Modified Base alternatives produced a large pool of surface water immediately downstream of the S-12 structures, while the Basic Rain-Driven and Modified Rain-Driven alternatives produced similar continuous surface water patterns within the eastern flow-way of Northeast Shark Slough (see Figure 17). Under below normal dry season conditions, all of the alternatives produced a complete drydown of the western Shark Slough Basin (see Figure 18).

Under above normal wet season conditions nearly 90 percent of the western and central slough would be covered by deep water under all of the alternatives (see Fig. 19). During the 1970 dry season, the amount of deep water within western Shark Slough remained at just over 60 percent for the Base, Modified Base, and Basic Rain-Driven alternatives, but was 14 percent higher for the Modified Rain-Driven alternative. Figure 20 indicates that the two rain-driven alternatives maintained a continuous flow-way of deep surface water throughout the dry season. In contrast, the Modified Base alternative produced a series of isolated deep water pools.

Hydroperiods in Western and Central Shark Slough

The annual hydroperiod data for the four proposed alternatives throughout all 14 years is summarized in Table 4 of Appendix A. The table indicates that for the selected normal hydrologic year (June 1976 through May 1977) the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives slightly reduced the percentage of the basin in the long hydroperiod classes. The largest reductions occurred under the two rain-driven alternatives. The Basic Rain-Driven and Modified Rain-driven alternatives reduced the percentage of the basin in 10 to 12 month hydroperiods by 17 and 14 percent, respectively, while decreasing the maximum area of surface water inundations by less than 2 percent. Figure 21 indicates that these areas of reduced hydroperiods occurred primarily in the higher elevated portion of the upper basin, immediately downstream of the S-12 structures.

During the selected dry year (June 1974 through May 1975) all of the alternatives produced complete drydowns over approximately 7 to 9 percent of the basin (see Table 4, Appendix A). The two rain-driven alternatives again substantially reduced the percentage of the basin in 10 to 12 month hydroperiods, by shifting these areas into the 4 to 6 and 7 to 9 month categories. Figure 22 shows that these hydroperiod reductions occurred primarily in the central portion of the slough.

Under very wet conditions (such as in the June 1969 through May 1970 period) over 90 percent of the basin remained in the 10 to 12 month hydroperiod class for all of the alternatives. Figure 23 shows only minor differences in the surface water patterns under the four alternatives.

Surface Water Depths in Water Conservation Area 3A

Hydrographs for the two stations in Water Conservation Area 3A (3A-4 and 3A-28) are shown in Figure 25. The hydrograph of station 3A-4 indicates that in the central portion of the basin average wet season water levels were nearly identical for the four alternatives. During the dry season average water levels were again the same for the Base and Modified Base alternatives, but were substantially higher under the two rain-driven alternatives. For the Basic Rain-Driven alternative average water level increases ranged from 0.09 to 0.28 feet, and increases ranged from 0.11 to 0.42 feet under the Modified Rain-Driven alternative. These increases produced only a minor increase in the average annual hydroperiod for this station.

The hydrograph for station 3A-28 in the southeastern impounded portion of WCA 3A showed much more significant water level changes in response to the four alternatives. Again the average wet season water levels under the Modified Base and Modified Rain-Driven alternatives were nearly identical to the Base alternative, but water level declines of 0.09 to 0.80 feet occurred under the Basic Rain-Driven alternative. During the early dry season (December through March) average water levels increased by 0.21 to 0.43 feet under the Basic Rain-Driven alternative, while water levels increased by 0.13 to 0.34 feet under the Modified Rain-Driven alternative. During the late dry season (April and May) average water levels under the Basic Rain-Driven alternative were 0.07 to 0.39 feet lower than the Base alternative, and were on average 0.05 feet lower under the Modified Rain-Driven alternative during May.

Table 5 in Appendix A summarizes the seasonal water depth characteristics throughout Water Conservation Area 3A. The table indicates that under average wet season conditions (June through November) the four alternatives had nearly identical percentages for all water depth classes. The water depth data for the selected normal wet season (1976) indicates that approximately 74 percent of the area was in deep water for all of the alternatives. The average wet season water depth distribution map for the end of October (Fig. 15) shows that the Base,

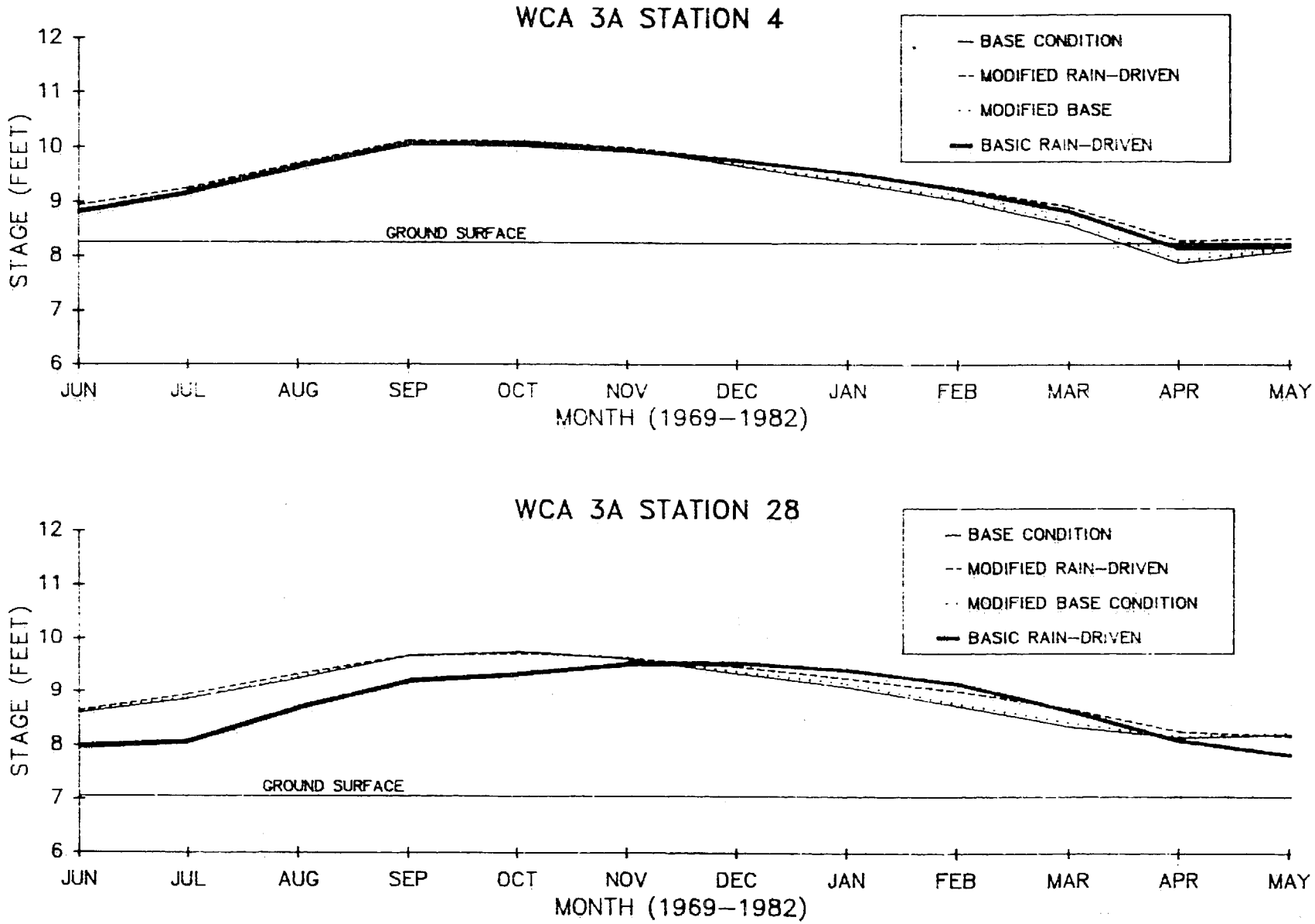

Figure 25. Surface water hydrographs for stations 3A-4 and 3A-28 in Water Conservation Area 3A.

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Modified Base, and Modified Rain-Driven alternatives maintained a large pool with more than two feet of surface water covering nearly 50 percent of the basin. In contrast, the Basic Rain-Driven alternative substantially reduced this pool of very deep water, particularly in the lower portion of WCA 3A.

Under average dry season conditions (December through May) the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed an overall increase in water depths over the Base (BA) alternative (see summary statistics in Table 5, Appendix A). The water depth data for the 1976-77 (average year) dry season indicates a similar trend, with the two rain-driven alternatives producing a 10 to 12 percent increase in the area of deep surface water. Figure 16 shows that by the end of April 1977, nearly all of this deep water was gone. The Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed substantially more water remaining in WCA 3A than the Base alternative, with the two rain-driven alternatives maintaining the largest area of continuous surface water.

During below normal wet season conditions, such as the selected period from June through November 1974, all of the alternatives had approximately 60 percent of the area in deep water. Figure 17 indicates that 35 to 50 percent of WCA 3A was covered by more than two feet of surface water under the Base, Modified Base, and Modified Rain-Driven alternatives. The Basic Rain-Driven alternative again substantially reduced the area of very deep water, particularly in the lower portions of WCA 3A adjacent to the L-29 levee.

Under below normal dry season conditions, such as the period from December 1974 through May 1975, the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives produced substantial increases in the percentage of the basin that was in deep water. Figure 18 indicates that by the end of the dry season (April 1975) most of WCA 3A experienced a complete drydown. The Base, Modified Base, and Modified Rain-Driven alternatives did maintain a small, but discontinuous shallow pool of surface water adjacent to the L-67A canal. In contrast, under the Basic Rain-Driven alternative, a small area of WCA 3A maintained several scattered surface water pools.

Under above normal wet season conditions, such as in the selected period from June 1969 through November 1969, over 95 percent of WCA 3A was covered by more than two feet of surface water under all of the alternatives (see Table 5, in Appendix A and Figure 19). During the 1970 dry season, the amount of deep water in WCA 3A remained at just over 80 percent for the Base and Modified Base alternatives. Under the Basic Rain-Driven and Modified Rain-Driven alternatives the percentage of deep water increased by 7 to 9 percent, respectively. Figure 20 shows that by the end of the dry season, the area of very deep water was reduced substantially under the Base, Modified Base, and Basic Rain-Driven alternatives, but remained high for the Modified Rain-Driven alternative.

Hydroperiods in Water Conservation Area 3A

The hydroperiod data in Table 6 of Appendix A indicates that for the selected normal hydrologic year (June 1976 through May 1977), all of the alternatives maintained 10 to 12 month hydroperiods for over 95 percent of WCA 3A. Figure 21 shows that the two rain-driven alternatives maintained larger areas of 12 month hydroperiods than the Base or Modified Base alternatives under this selected normal year.

During the selected dry year (June 1974 through May 1975) all of the alternatives had similar percentages of the area with hydroperiods in excess of 7 months, but the Modified Rain-Driven alternative more than doubled the area of 10 to 12 month hydroperiods as compared to the Base alternative (see Table 6, Appendix A). The Modified Base and Basic Rain-Driven

alternatives both showed increases in the percentage of the area with long hydroperiods, but these increases were modest. Figure 22 shows that a large increase in the percentage of long hydroperiod areas occurred under the Modified Rain-Driven alternative, but an unusual area of reduced hydroperiods in the southeastern corner of WCA 3A occurred under the Basic Rain-Driven alternative. The cause of this pattern of drying under the Basic Rain-Driven alternative cannot be explained by the proposed structural and operational changes.

Under very wet conditions (such as in the June 1969 through May 1970 period), 100 percent of WCA 3A was in the 10 to 12 month hydroperiod class (see Table 6, Appendix A). Figure 23 shows that under these high water conditions there were no significant differences in the surface water patterns in WCA 3A under the four alternatives.

Surface Water Depths in Water Conservation Area 3B

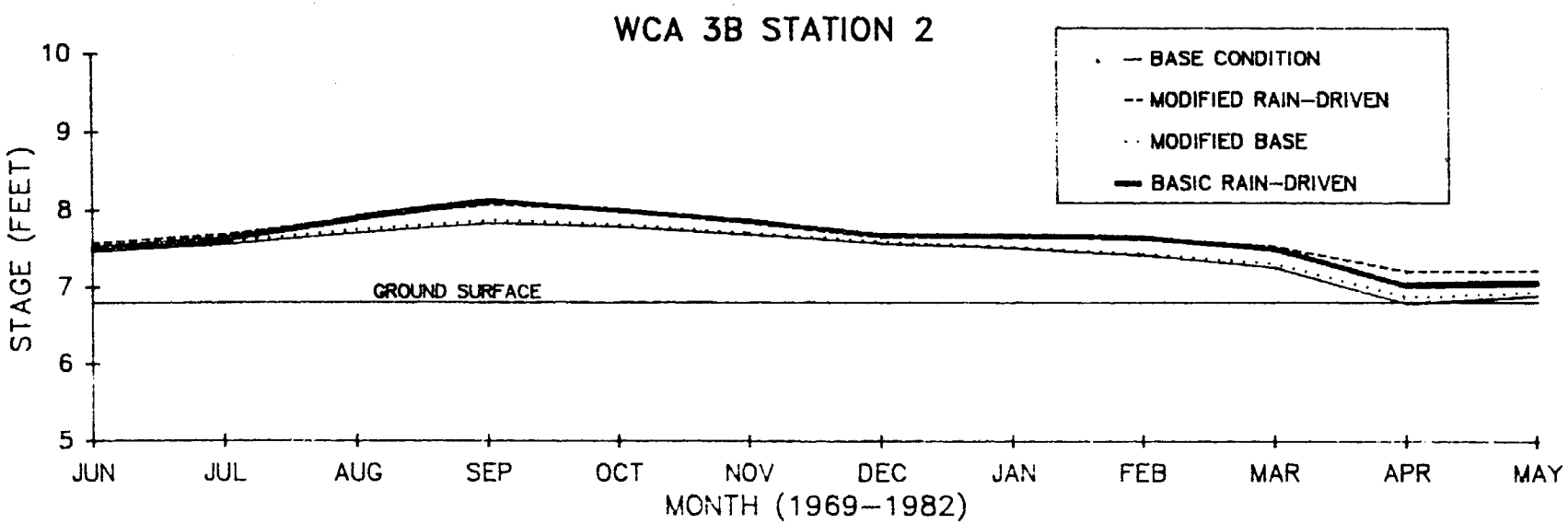
Hydrographs for the two stations within Water Conservation Area 3B (3B-2 and 3B-29) are shown in Figure 26. The hydrograph for station 3B-2 indicates that in the portion of the basin downstream of the proposed S-345 structures average water levels would increase throughout the year due to the transfer of surface water from WCA 3A directly into WCA 3B as proposed under the two rain-driven alternatives. Average annual water level increases ranged from 0.06 to 0.28 feet under the Basic Rain-Driven alternative and increases ranged from 0.08 to 0.42 feet under the Modified Rain-Driven alternative. These increases lengthened the average annual hydroperiod for this station by approximately one month.

The hydrograph for station 3B-29 indicates that in the southeastern portion of the basin only slight water level increases would occur during the wet season. During the dry season, average water level increases ranged from 0.06 to 0.38 feet under the Basic Rain-Driven alternative and from 0.08 to 0.45 feet under the Modified Rain-Driven alternative. These water level increases lengthened the average annual hydroperiod by less than one month.

Table 7 in Appendix A summarizes the seasonal water depth characteristics throughout Water Conservation Area 3B. Under average wet season conditions (June through November) the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives showed increases in the percentage of deep water within WCA 3B. The Modified Rain-Driven alternative caused the greatest increase with 14 percent more deep water than the Base alternative (see summary statistics in Table 7, Appendix A). The water depth data for the selected normal wet season (1976-77) indicates that from 64 to 77 percent of the area was in deep water for all of the alternatives, with the greatest percentage occurring under the Modified Rain-Driven alternative. The water depth distribution map for the end of October 1976 (Fig. 15) shows that a large pool of one to two feet deep water covered all of WCA 3B, under all four alternatives.

Under average dry season conditions (December through May) the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives again showed increases in water depths over the Base alternative (see summary statistics in Table 7, Appendix A). The water depth data for the 1977 dry season indicates a reversal of this trend, with substantially less deep water under the two rain-driven alternatives. Figure 16 shows that by the end of April 1977, nearly all of WCA 3B was dried out. The two rain-driven alternatives maintained approximately the same amount of surface water, while the Modified Base alternative maintained a modest pool over much of the western half of WCA 3B.

Under below normal wet season conditions, such as the selected period from June through November 1974, the Base, Modified Base, and Basic Rain-Driven alternatives all maintained approximately 20 percent of the area in deep water, while the Modified Rain-Driven alternative



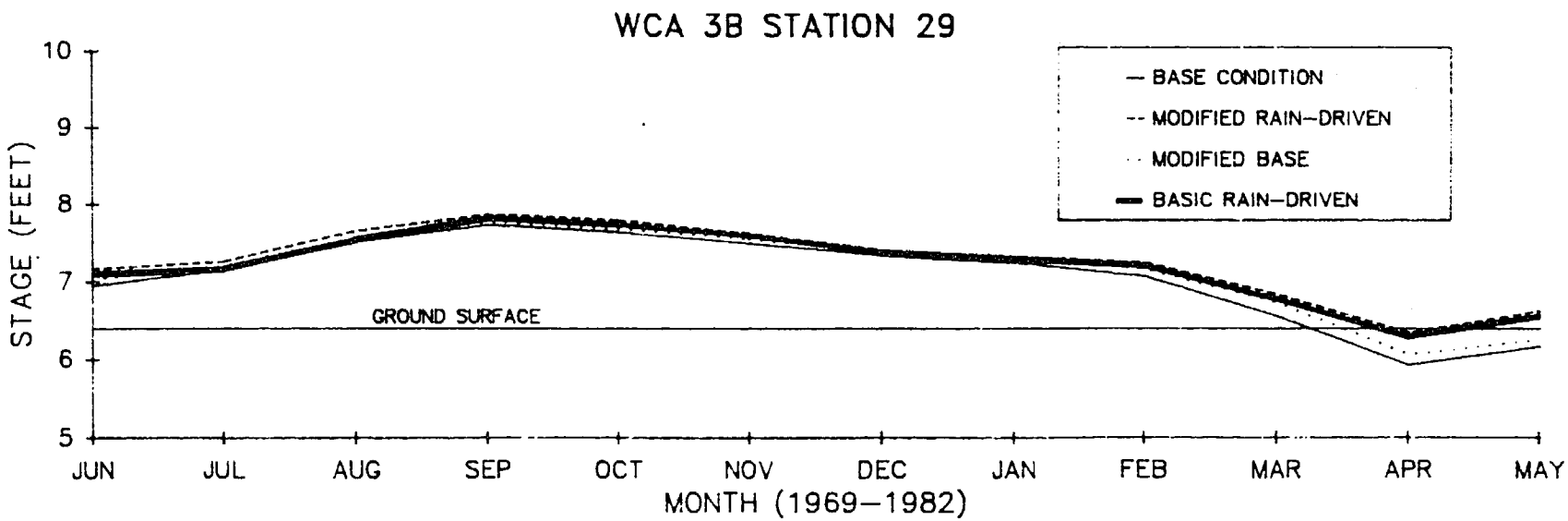


Figure 26. Surface water hydrographs for stations 3B-2 and 3B-29 in Water Conservation Area 3B.

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maintained approximately 30 percent (see Table 7, Appendix A). Figure 17 shows that during October 1974, a large pool of shallow surface water covered all of WCA 3B, under all four alternatives. The two rain-driven alternatives had scattered deeper water areas within the basin.

Under below normal dry season conditions, such as the period from December 1974 through May 1975, between 30 and 39 percent of WCA 3B completely dried out under all four alternatives. Figure 18 indicates that by the end of April 1975, most of WCA 3B experienced a complete drydown. The Modified Rain-Driven alternative maintained a small area of surface water in the southwestern corner of WCA 3B when the other alternatives did not.

Under above normal wet season rainfall conditions, such as in the selected period from June 1969 through November 1969, 93 percent of WCA 3B was be covered by more two feet of surface water under the Base alternative. This percentage increased to 100 percent for the two rain-driven alternatives (see Table 7, Appendix A and Figure 19). During the 1970 dry season, the amount of deep water in WCA 3B remained at just over 80 and 90 percent for the Base and Modified Base alternatives, respectively. The Basic Rain-Driven and Modified Rain-Driven alternatives maintained deep water over essentially all of the basin. Figure 20 shows that by the end of the 1970 dry season, the area of very deep water was reduced under the Modified Base, and Basic Rain-Driven alternatives, but remained high for the Base and Modified Rain-Driven alternatives.

Hydroperiods in Water Conservation Area 3B

The hydroperiod data in Table 8 of Appendix A indicates that for the selected normal hydrologic year (June 1976 through May 1977), all of the alternatives maintained 10 to 12 month hydroperiods over approximately 90 percent of WCA 3B. Figure 21 indicates that the distribution of these long hydroperiod areas was similar for the four alternatives.

During the selected dry year (June 1974 through May 1975) the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives had higher percentages of the basin with hydroperiods in excess of 10 months then the Base alternative. The Modified Base alternative had the highest percentage with over 65 percent of WCA 3B in the 10 to 12 month hydroperiod class (see Table 8, appendix A). Figure 22 shows nearly identical patterns for the two rain-driven alternatives, and the shortest hydroperiods under the Base alternative.

Under very wet conditions (such as in the June 1969 through May 1970 period), 100 percent of WCA 3B was in the 10 to 12 month hydroperiod class for the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives (see Table 8, appendix A). The Base alternative had 94 percent of the basin in 10 to 12 month hydroperiods. Figure 23 shows essentially no differences in the pattern of hydroperiods under the four alternatives for this very wet year.

Shark Slough Flow Volume Comparisons

A comparison was made between the seasonal and annual Shark Slough flow volumes under actual conditions and under the four proposed alternatives, to determine the overall impacts of the alternatives on total water deliveries to the basin. Figure 27 is a plot of total annual discharges to the Shark Slough Basin for the actual and three of the proposed alternatives. The Modified Base alternative was omitted since its annual total flow was generally within

2,000 to 3,000 acre-feet of the Base alternative. Table 6 similarly lists the wet and dry season total flows and the 14-year test period average flows through the two Shark Slough flow sections under the actual and projected model alternatives. Note that flows to Shark Slough were highly variable throughout the 14-year test period under all of the alternatives and under actual conditions.

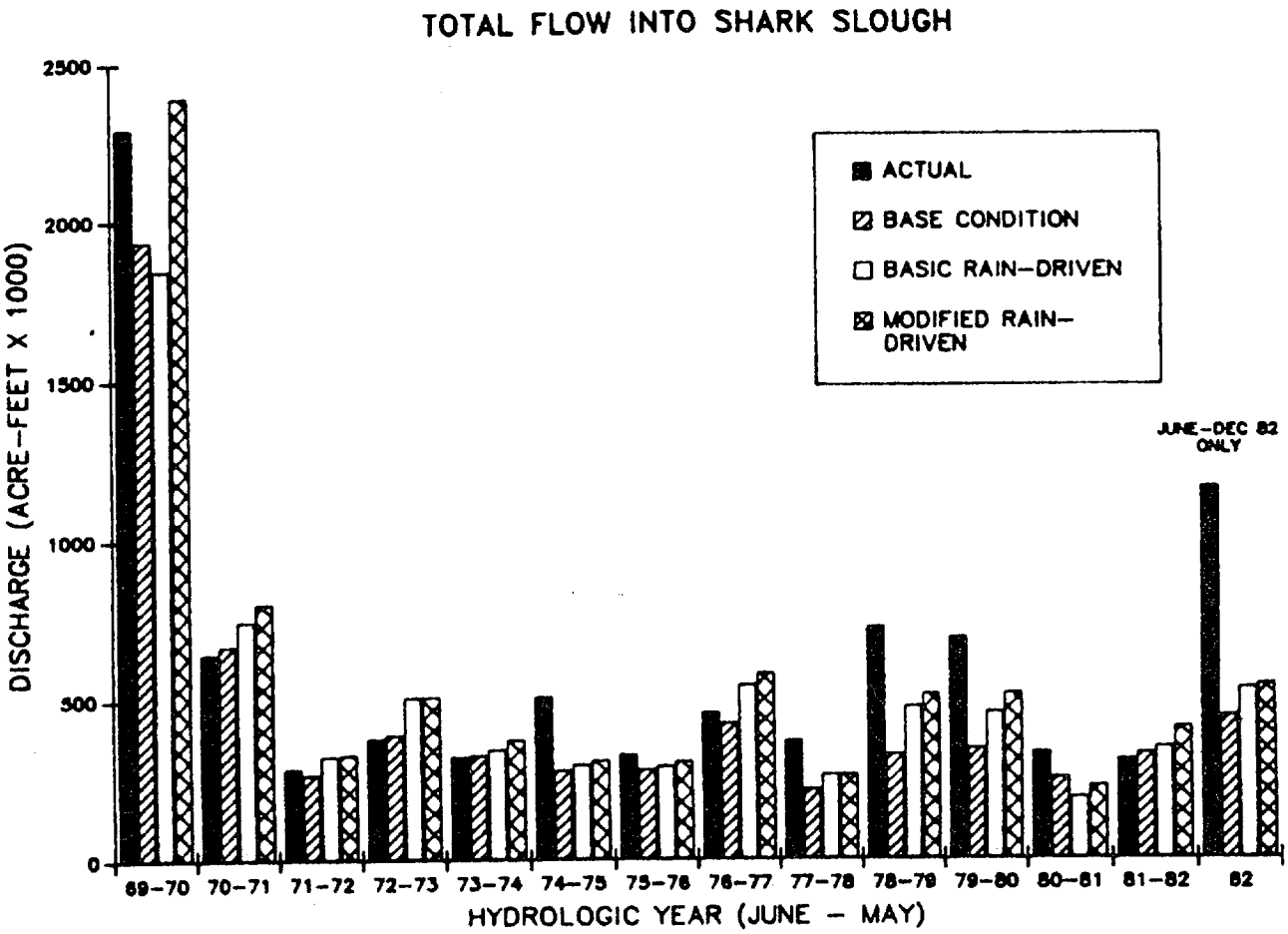

Figure 27. Comparison of the total annual flows into Shark Slough under actual conditions, and three of the proposed alternatives.

Actual annual discharges were in excess of 1,000,000 acre-feet during two years, and in excess of 500,000 acre-feet, during five of the 14 test years. In contrast, flows under the Base and Modified Base alternatives were in excess of 1,000,000 acre-feet during only one year (1969-1970) and were in excess of 500,000 acre-feet during only two years. These differences were unexpected, since the Base and Modified Base alternatives follow the same Minimum Delivery Schedule for deliveries to Shark Slough as was in effect during 1970 through 1982. A major drought occurred throughout the Southern Everglades during the 14-year test period, and four of the 14 years (71-72, 73-74, 75-76, and 81-82), produced flows that were equal to or only slightly higher than the Congressionally mandated Minimum Delivery Schedule under actual conditions. During two of these dry years (73-74 and 81-82) the Base and Modified Base alternatives produced substantially higher flows into Shark Slough, potentially relieving some of the drought impacts.

Table 6. Seasonal flow totals for the two Shark Slough flow sections under actual conditions and the four proposed alternatives.

YEAR	SEASON	BAS12	BANES	BASUM	BCS12	BCNES	BCSUM	MUS12	MUNES	MUSUM	MPS12	MPNES	MPSUM	ACTS12	ACTNES	ACTSUM
1969	DRY	148393	6942	155335	150868	6198	157066	54398	72943	127341	53959	73655	127614	316925	15349	332274
1969	WET	1174491	0	1174491	1181206	0	1181206	570105	479303	1049408	791469	440036	1231505	1229143	38212	1267355
1970	DRY	750149	12394	762543	757299	9916	767215	365417	429736	795153	709894	451779	1161673	932787	29460	962247
1970	WET	580894	992	581886	588218	496	588714	355050	369046	724096	406396	366853	773249	487691	36858	524549
1971	DRY	67697	20078	87775	67915	17104	85019	1975	19138	21113	3199	24002	27201	78701	2837	81538
1971	WET	175624	13137	188761	176216	11650	187866	72348	88904	161252	72247	92259	164506	162007	11115	173122
1972	DRY	70550	7686	78236	70549	5206	75755	71693	91186	162879	71693	92144	163837	85404	8313	93717
1972	WET	315919	248	316167	343721	248	343969	215350	210682	426032	198209	221509	419718	227349	28819	256168
1973	DRY	68056	7685	75741	68221	6197	74418	30350	53624	83974	39174	51695	90869	86290	4558	90848
1973	WET	239899	3222	243121	240541	2478	243019	157016	139815	296831	149385	174867	324252	190326	28018	218344
1974	DRY	68136	15864	84000	68327	15121	83448	14303	33864	48167	14303	35991	50294	72772	2301	75073
1974	WET	188113	6445	194558	188346	5205	193551	110499	124564	235063	109517	130475	239992	388029	13858	401887
1975	DRY	67855	17104	84959	68145	16113	84258	21258	40955	62213	22354	48070	70424	86576	4997	91573
1975	WET	189411	992	190403	189410	992	190402	116184	129482	245666	114260	138760	253020	195442	23356	218798
1976	DRY	70327	20822	91149	70385	18096	88481	13532	32797	46329	17121	35898	53019	73546	6243	79789
1976	WET	341448	744	342192	346678	744	347422	229278	226480	455758	233116	254944	488060	274703	47027	321730
1977	DRY	69969	13634	83603	70061	13139	83200	33247	57479	90726	35529	58584	94113	75923	7898	83821
1977	WET	143109	2975	146084	144321	1983	146304	60662	75735	136397	60723	76232	136955	198705	17614	216319
1978	DRY	70225	2231	72456	70228	992	71220	57327	70918	128245	57327	71168	128495	109416	13469	122885
1978	WET	244388	248	244636	257405	0	257405	167905	193989	361894	181373	220214	401587	444489	54378	498867
1979	DRY	70229	11898	82127	70229	10658	80887	48104	67517	115621	48104	66774	114878	119975	26114	146089
1979	WET	189365	248	189613	189410	248	189658	91541	112127	203668	107288	130934	238222	271425	17966	289391
1980	DRY	148865	6197	155062	187339	2727	190066	113549	142784	256333	123983	157020	281003	333900	25065	358965
1980	WET	176785	1736	178521	179677	1488	181165	64120	79923	144043	77745	96538	174283	226361	15954	242315
1981	DRY	67774	7685	75459	67978	5207	73185	14583	33193	47776	17387	36309	53696	75116	176	75292
1981	WET	232859	9172	242031	233594	9668	243262	139772	118296	258068	146468	171327	317795	193346	17928	211274
1982	DRY	69888	17105	86993	69941	13385	83326	25511	63966	89477	35329	57862	93191	67997	5871	73868
1982	WET	412986	248	413234	415492	248	415740	260628	247849	508477	246737	273799	520536	979931	61686	1041617
DRY MEAN		129151	11952	141103	132678	10004	142682	61803	86436	148239	89240	90068	179308	179666	10904	190570
DRY ST.D.		181024	5707	180873	183493	5618	183058	92146	103525	195574	181200	109147	289680	233968	9586	241057
WET MEAN		328949	2886	331836	333874	2532	336406	186461	185443	371904	206781	199196	405977	390639	29485	420124
WET ST.D.		270343	3987	268996	271984	3729	270757	138869	116898	254963	191281	106418	292780	322281	15949	332146

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During 1977-78 and 1980-81, the Base and Modified Base alternatives produced much lower flows than actual, and failed to meet the required Minimum Delivery Schedule by 47,000 and 15,000 acre-feet, respectively. Note that under actual flow conditions, Shark Slough received on average, 610,000 acre-feet annually, or an additional 138,000 acre-feet more water annually then the Base alternative. The Basic Rain-Driven and Modified Rain-Driven alternatives showed similar flow reductions, with Shark Slough receiving on average 91,000 to 26,000 acre-feet less water than under actual conditions (see Table 6). These large flow reductions are presumably a result of the 1990 land use and water demands inherent in all of the model runs.

In general, the Basic Rain-Driven, and Modified Rain-Driven alternatives delivered consistently lower flows than the Base alternatives during low rainfall periods, particularly during the dry season. In contrast, the wet season flows under the two rain-driven alternatives were higher then the Base alternatives, which produced greater annual total flows during all of the years except 1980-81. The Modified Rain-Driven alternative produced substantially higher flows than the Basic Rain-Driven alternative, particularly during the wet season (see Table 6). This lead to and average annual total flow increase of approximately 65,000 acre-feet. Again the large volume differences between the two rain-driven alternatives were due to increased regulatory flows, in response to the higher water levels maintained in WCA 3A under the Modified Rain-Driven alternative.

The Shark Slough flow volumes for the four alternatives were lastly compared to the flows generated under the natural system model. Although the model is not fully calibrated, the estimated flow characteristics are useful as a guide to the timing and volumes of flows that would have occurred in the absence of the current water management system. Figure 28 shows the average percentage of the total annual flows to Shark Slough that occurred each month under the natural system simulation model and three of the proposed alternatives. Again, the Modified Base alternative was omitted since the percentages are nearly identical to the Base alternative.

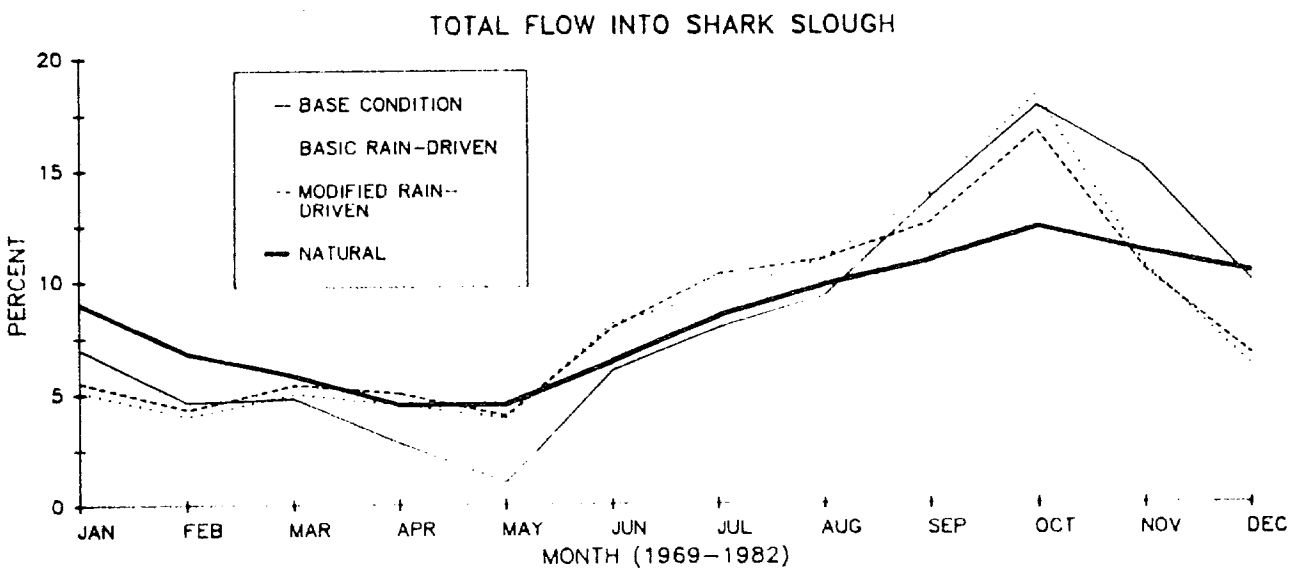

Figure 28. Monthly Shark Slough flow percentages for the natural system model and three of the proposed alternatives.

A number of general flow differences were observed. First, flows were substantially less variable, from month to month, or from year to year under the natural system model. The timing of flows was also substantially different, with approximately 60 percent of the total annual flows being delivered during the wet season (June through November), as compared to approximately 70 percent under all of the proposed alternatives. Figure 29 shows that average monthly flows during the peak of the wet season (August through November) were much lower under the natural system model. These reduced wet season flows and long recession periods indicate that much of the wet season rainfall that fell over the upstream wetlands did not reach Shark Slough until the early dry season. This long lag-time maintained persistent flows down the historical eastern flow-way, such that periods with no surface water flow into Shark Slough occurred infrequently, and lasted for generally no more than one month. All of these characteristics would be expected in a natural system, where large rainfall events would be attenuated by slower surface water flow rates through the marsh, and affects of upstream wet season rainfall would not be observed in Shark Slough until several months later.

These general observations suggest that restoration of natural surface water flows through the Southern Everglades may not necessarily require additional flow volumes. Further adjustments in the timing and distribution of surface water flows, such as those made under the experimental delivery program, should produce much of the required hydrologic improvements. Re-establishment of the wet season pool in WCA 3B must be a major part of this restoration effort, since higher stages in WCA 3B provides the hydrologic gradient needed to maintain flows down the eastern flow-way. This eastern flow-way must be re-established so that more persistent flows reach the downstream areas of Shark Slough and the lower estuaries.

Water Quality Implications for the Four Alternatives

The quality of waters entering Water Conservation Areas 3A and 3B or the park is dependent on the sources of the water and how water is managed in the upstream basins. Water budget studies for WCA 3A indicate that approximately two-thirds of the water held in storage is derived from local rainfall over the basin. The surface water in the WCA 3A wetlands away from water delivery sources is relatively unimpacted. In contrast, water delivered to the basin from the Everglades Agricultural Area, Lake Okeechobee, or the upstream Water Conservation areas commonly contain high concentrations of contaminants.

Under the two rain-driven alternatives, water deliveries from WCA 3A into WCA 3B or into Shark Slough are controlled primarily by local rainfall. Under these alternatives, the quality of delivered water is generally better because the water is derived from marsh flow through WCA 3A in response to rainfall events. The additional S-349 culverts that will be constructed in the L-67A canal should also improve overall water quality in the lower impounded area of WCA 3A and western Shark Slough, by diverting canal flows out into the marsh. However, these receiving wetlands may be impacted by degraded water from upstream areas.

Under the Base and Modified Base alternatives, water deliveries are required throughout the year regardless of the local rainfall conditions. During low water periods in WCA 3A surface waters have to be brought into the basin from the upstream WCAs or from the lake, which increases the potential for water quality degradation. This increased threat of contamination is a consequence of the source of this water, and not directly related to the water delivery scheme for the park. Any water management changes needed to address these potential water quality concerns must be addressed in the upstream areas where the pollutants are introduced.

The redistribution of surface waters under the two rain-driven alternatives will not solve the regional water quality problems, but the spreading of canal flow out into the wetlands may result in localized water quality improvements in the downstream areas. The long-term resolution of these water quality problems will require improvements upstream of the Water Conservation Areas that assure that the water delivered to these areas is consistent with background marsh water quality.

POTENTIAL IMPACTS OF THE FOUR ALTERNATIVES ON THE AMERICAN ALLIGATOR AND WADING BIRDS

Alligator Population Submodel Results

A comparison of simulated alligator population parameters resulting from the natural system simulation model and the four proposed alternatives is presented in Table 7. Average alligator population sizes for the 14-year evaluation period were approximately one-third greater under the natural system model than for any of the proposed alternatives. Peak population sizes under the natural system model were more than twice that of maximum population sizes obtained for the proposed alternatives, and minimum population sizes were also greater under the natural model. Of the four proposed alternatives, the Basic Rain-Driven alternative produced the highest average population estimate for the overall study area, while the Modified Rain-Driven alternative produced the next highest average population estimate.

Table 7. A comparison of simulated alligator population parameters for the natural system model and the four proposed alternatives within the overall study area.

Water Deliveries	Population Estimates			Average % Nest. Success	% Freq. Sign. Nest Flooding
	Average	Maximum	Minimum		
Natural	178000	350000	125000	93	7
Base	116300	152000	92500	81	19
Mod. Base	124600	155000	95000	72	28
Basic Rain	131750	155000	92500	69	31
Mod. Rain	125250	155000	92500	68	32

Nesting success under the natural model was also significantly greater, and the frequency of significant nest flooding only one-fourth that of the four proposed alternatives. The differences in predicted alligator population sizes for the natural system simulation model were related to increased nesting effort and success and reduced drought-related mortality. This increased nesting effort was apparently a result of the increased stage durations that occurred during the

peak mating period (late April/early May). The natural system model also produced an increase in the overall area of suitable nesting habitat. Under the four proposed alternatives, excessive water depths were maintained in southern WCA 3A which reduced the overall area of suitable nesting habitat within the study area.

The peak nest construction and egg laying period for alligators in the Everglades occurs during the early wet season. Egg clutches within the nest are deposited approximately one-half foot above prevailing water levels at the time of egg deposition. Increasing water depths during the incubation period under the natural system model rarely inundated the egg clutches, significantly reducing the occurrence of nest flooding compared to the other alternatives. Consistent and significant flooding of alligator nests occurred downstream of the S-12 structures for most years of the evaluation period under the Base and Modified Base alternatives, and in northwest WCA 3A for all four of the proposed alternatives. Figure 29 depict the typical distributions of alligator nest flooding that occurred under the four proposed alternatives. The extent of alligator nest flooding within Everglades National Park was greatly reduced (by approximately one-third) under the Basic Rain-Driven alternative compared to the other alternatives.

Although the two rain-driven alternatives had slightly lower nesting success rates, due to higher nest flooding over the study area, the more natural surface water distributions resulted in greater numbers of alligators nesting annually throughout the study area. This produced larger average population sizes within the evaluation area during the 14-year period. Typical alligator nest distribution patterns for the four alternatives are presented in Figure 30. Note that alligator nest distributions within Everglades National Park shifted toward more natural patterns (increased occupancy of the historical channel of Shark Slough) under the two rain-driven alternatives.

Wading Bird Colony Site Sub-model Results

A comparison of wading bird-colony site nesting success for the natural system model and the four proposed alternatives is presented in Table 8. Three major grassland colony sites within the study area were selected for the analysis. Impacts of the four alternatives on wading bird nesting effort at more traditional colony sites could not be directly assessed since all of these sites occur within the mangrove estuaries outside of the defined study area. The average frequency of annual nesting success for grassland colony sites under the natural system model was twice that obtained under any of the four proposed alternatives. This was true for the nesting sites in both the Water Conservation Areas and in Shark Slough.

The colony site model responses for the four proposed alternatives are in general agreement with the frequencies of nesting success in the published literature for wading birds in grassland colony sites from post water management to the present time. Overall colony success rates in the 25 - 50 percent range, as predicted for the four alternatives, are also approximately the same as those that reported at grassland colony sites within the Central and Southern Everglades since the late 1960's (NPS and National Audubon Society data). These frequencies of nesting success, however, represent a significant decrease in the proportion of the total number of wading birds that actually nested in the Everglades under pre-project conditions. Estimates of the number of nesting wading birds in the mid 1970's of approximately 25,000 pairs compared to recent estimates in the late 1980's of only 5,000 - 8,000 nesting pairs represent an 80 to 88 percent decrease in nesting effort over the past 25 years.

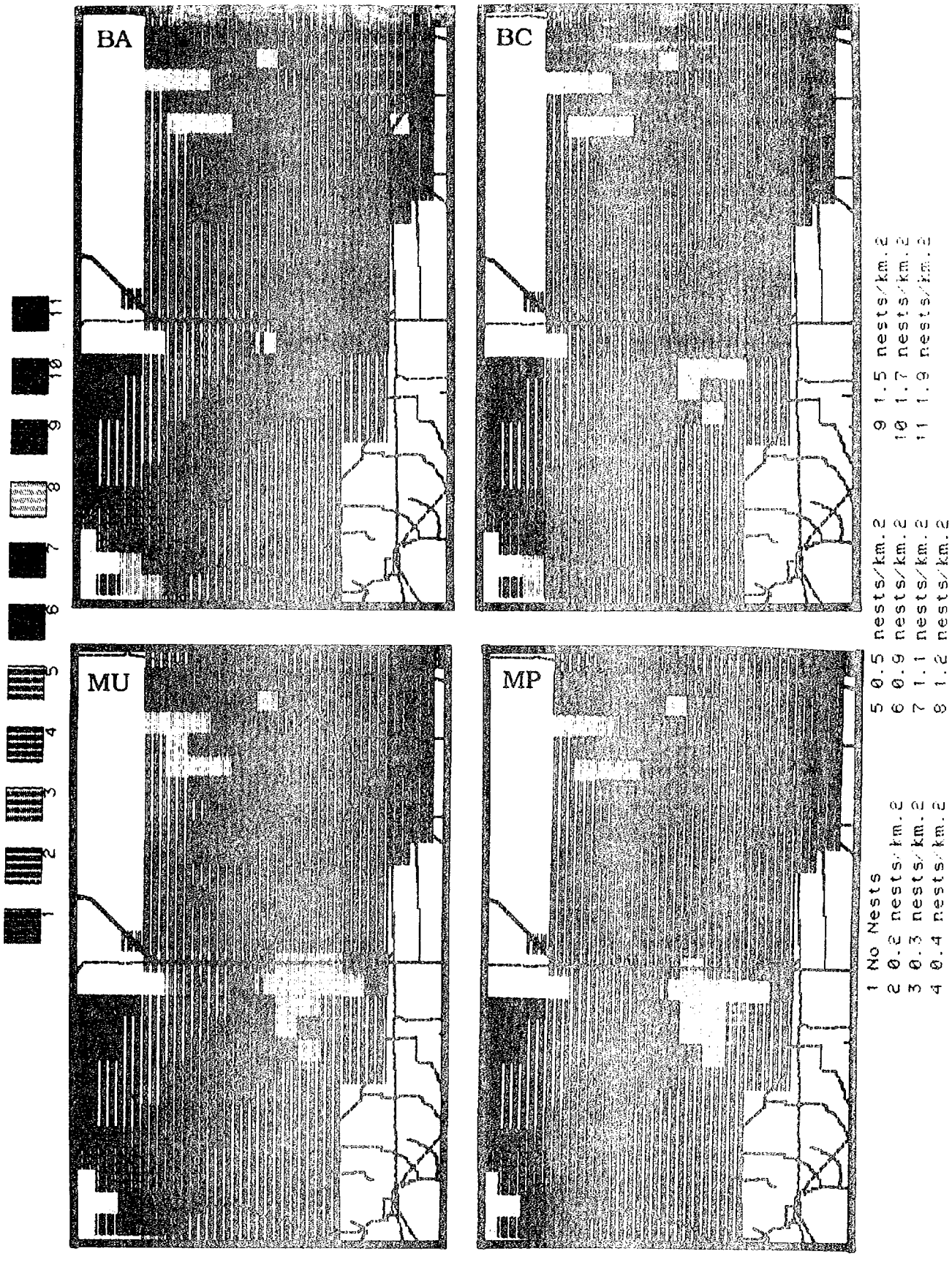

Figure 29. Typical patterns of alligator ~~nest flooding~~ nesting for the four proposed alternatives; Base (BA), Modified Base (BC), Basic Rain-Driven (MU), and Modified Rain-Driven (MP).

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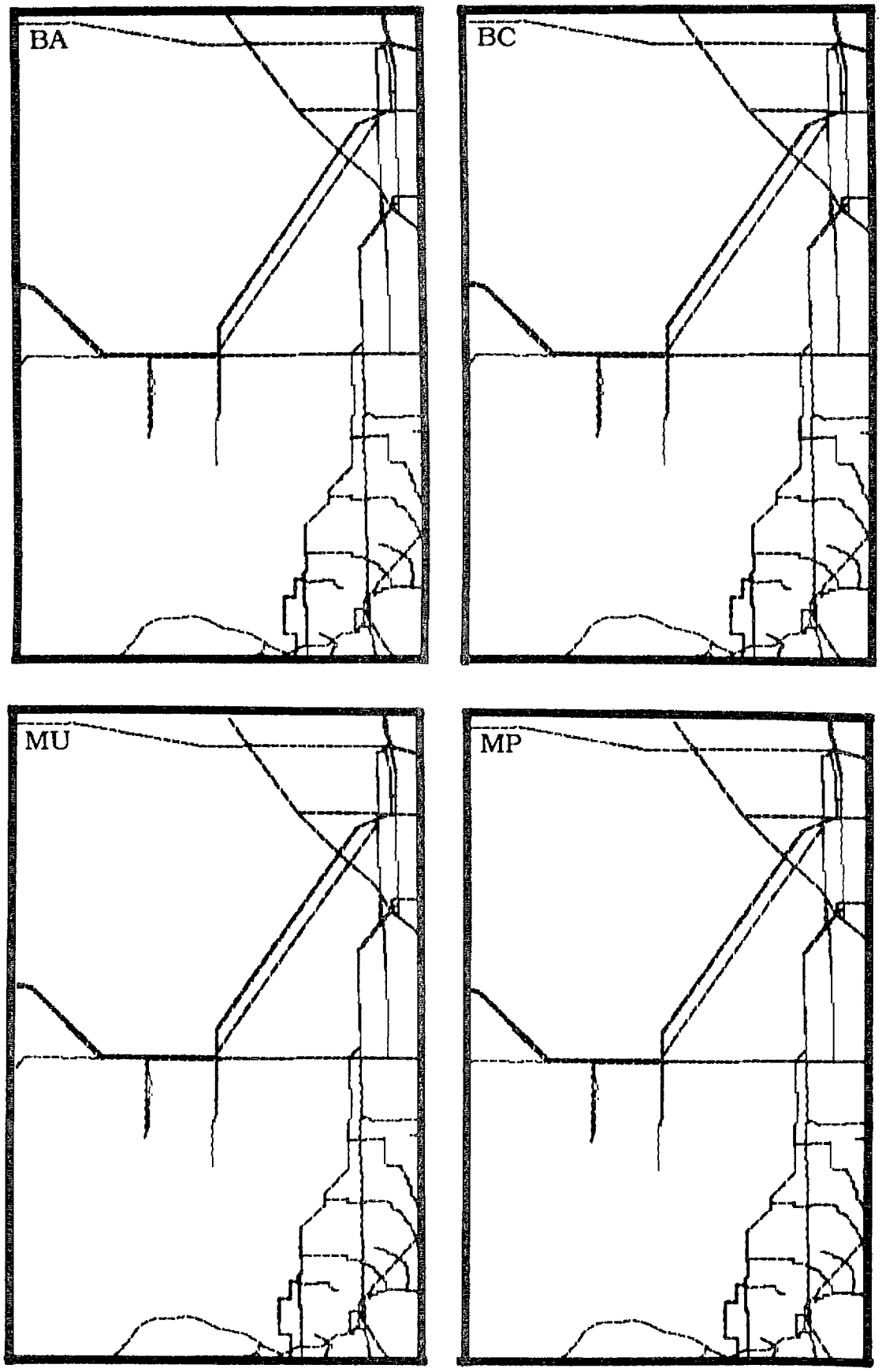

Figure 30. Typical patterns of alligator nest flooding for the four proposed alternatives; Base (BA), Modified Base (BC), Basic Rain-Driven (MU), and Modified Rain-Driven (MP).

Table 8. Predicted wading bird colony site nesting success for the period 1969-1982, for natural system model and the four proposed alternatives.

Colonies	Natural	Base	Mod. Base	Basic Rain	Mod. Rain
Site 1	93%	0%	0%	0%	0%
Site 2	86%	71%	57%	36%	57%
Site 3	86%	71%	86%	43%	64%
14-year Mean Colony Success Rate	88%	47%	48%	26%	40%

Under pre-project conditions, most wading birds did not nest in grassland colony sites, but at sites within the mangrove-headwaters of the Shark Slough and Taylor Slough estuaries. Greater numbers of wading birds nested successfully in these historical estuary rookery sites than nest now in the grassland colony sites. Since the completion of the WCAs in 1962, two-thirds of all wading bird nesting has occurred in these impounded marshes during moderate to low rainfall years. The importance of re-establishing maximum areas of surface water during the early dry season near the traditional colony sites within these downstream estuaries is depicted in Figure 31 (Fleming *et al.*, in prep. [b]). In higher rainfall years nesting distributions are evenly divided between the grassland sites in the WCAs and the downstream estuaries of the Southern Everglades (Fleming et al., in prep. [b]). The impoundment of the northern reaches of the Everglades, and the subsequent reduction in dry season flows to the Southern Everglades and downstream estuaries, correlates well with the decline in use of these estuarine areas by nesting wading birds. This shift in the location of wading bird nesting sites has occurred in response to changes in upstream water management (Ogden, in prep.).

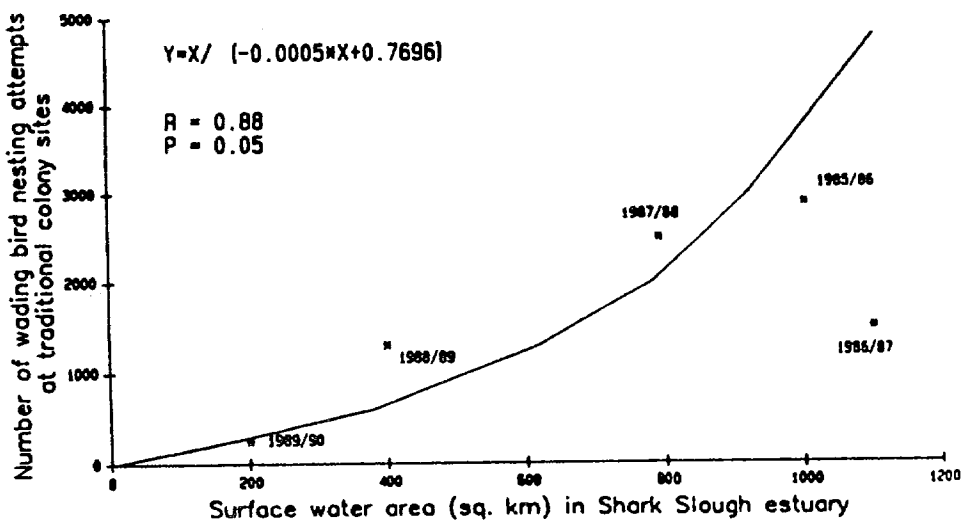

Figure 31. Relationship between annual wading bird nesting effort at traditional colony sites and surface water area in the Shark Slough estuary during the early dry season, 1986-1990 (NPS unpublished data).

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POTENTIAL IMPACTS OF THE FOUR ALTERNATIVES ON WOOD STORKS

The Wood Stork has become an important indicator species for the biological vitality of the Everglades ecosystem for two reasons. First, the Wood Stork is a specialist of Everglades-like ecosystems throughout its range. Thus, year-to-year responses by storks closely reflect the ability of the ecosystem to support storks and other wading birds. Second, a more quantitative and long-term database exists for the Wood Stork than for most other Everglades vertebrates. Long-term trends in Wood Stork numbers and nesting patterns can therefore provide one important measure of the degree of change in the system, and indicate where (ecologically and geographically) these changes are occurring.

This section reviews the relationships between the reproductive ecology of the Wood Stork in the Everglades region and the hydrology of the system. These relationships need to be understood as a basis for evaluating the relative merits of the four proposed alternatives. Since the relationships between stork nesting patterns and hydrology were different in the natural or pre-project Everglades ecosystem than exist in the present hydrologically altered ecosystem, both sets of relationships are described. It is important to understand the more natural relationships, since recovery to those conditions is an essential part of the ecosystem restoration goals for Everglades National Park.

Data on Wood Stork reproductive patterns collected by NPS personnel for the years 1953-1961 were used as a way of quantifying the natural relationships that existed prior to completion of the canals, levees, and water control structures along the northern and eastern boundaries of the park. Although many hydrological changes had occurred in the Everglades by the 1950's, the reproductive patterns during those years were similar to the patterns described less quantitatively by National Audubon Society wardens for 1930-1939 (J. Ogden, in prep.). The characteristics of the post-project reproductive patterns were similarly developed from annual data collected at colony sites within the park and the Water Conservation Areas between 1962 and 1990.

Pre-Project Reproductive Patterns

Under natural, pre-project conditions Wood Storks returned to the Central and Southern Everglades each year during October to November, at the beginning of the dry season. With few exceptions, nesting colonies formed during November to December. With this reproductive schedule, stork nests contained young birds, and nestlings were fledging, during the period from February through May when the highest potential food concentrations were available in the drying system. At the initiation of the rainy season in May to June, adults and newly fledged young dispersed north to escape the Everglades region during the months of high water and relatively poor feeding conditions.

Three important characteristics of Wood Stork reproductive dynamics in the natural system were:

1) Storks formed nesting colonies in November or December in most years, regardless of early dry season drying rates in the Everglades (Table 9).

2) Stork colonies were larger and more often successful in years of relatively high water than in years of relatively low water (Table 10).

3) The number of pairs in colonies varied considerably between years, but there were years, on a regular basis, in which a high percentage of the estimated total breeding population attempted to nest (Fig. 32).

Table 9. Timing of Wood Stork colony formation, and number of nesting pairs, related to early dry season drying rates in the Southern Everglades, 1953-1961.

Nesting Season	# Pairs	Nov-Jan Drying Rate P-33	Nov-Jan Drying Rate G-789	Month of Colony Formation
1952-53	N/D	0.0045	.0201	Dec
54	N/D	.0050	.0240	Dec
55	3000	.0050	.0256	Nov
56	1250	.0054	N/D	Nov
57	750	.0060	.0553	Jan
58	600	-0.0004	-0.0478	Dec
59	2200	.0045	0.0131	Nov
60	2500	.0063	.0320	Dec
61	2500	.0116	.0198	Nov
		0.0066(4)	.0195(3)	Nov
		.0052(3)*	.0253(3)*	Dec
Means		.0060(1)	.0553(1)	Jan
		.0060	.0271	All Years
# pairs when drying rate > mean		1916	1625	
# pairs when drying rate < mean		1762	2075	

Drying rates are expressed as the average daily change (feet per day) between the highest November and highest January water levels at two representative gauges (P-33 in north-central Shark Slough and G-789 in the Taylor Slough headwaters). *Excludes (-) values.

Table 10. Water levels, number of nesting pairs and nesting success for Wood Storks in the Southern Everglades, 1955-1961.

	Previous wet season high P-33	Previous wet season high G-789	No. Nesting Pairs	Success/ Failure
1954-55	7.12	6.91	3000	Succ.
56	6.37	5.53	1250	Fail.
57	5.81	5.20	750	Fail.
58	6.81	4.10	600	Fail.
59	7.17	6.37	2200	Succ.
60	7.26	7.00	2500	Succ.
61	7.67	7.14	2500	Succ.
Means	7.30	6.86	2550	Succ (4)
	6.33	4.94	866	Fail (3)

Water levels are for two representative gauges (P-33 in north-central Shark Slough and G-789 in the Taylor Slough headwaters). Success is defined as 50 percent or more of the potential nesting population attempting nesting, and an average of 1.0 chicks or more fledged per nesting attempt.

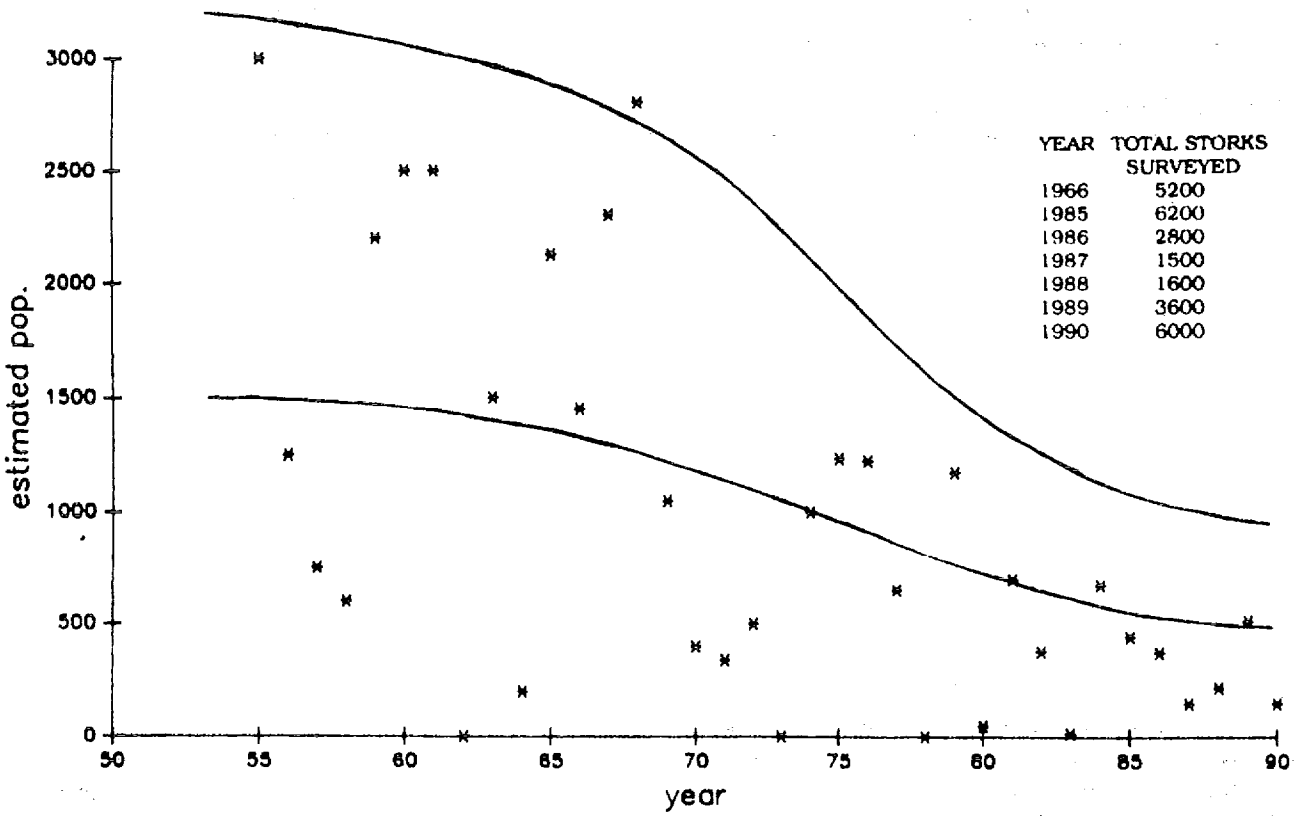

Figure 32. Hypothetical estimate of the potential Wood Stork breeding population in the Southern Everglades, based on actual numbers of nesting pairs, 1955-1990, and total number of storks detected during aerial surveys.

Reproductive Patterns after Water Management

Similar to the natural system, Wood Storks return each year to the Everglades region at the beginning of the dry season, and disperse northward when the summer rainy season begins. The significant difference is in timing of nesting, with colony formations now occurring much later, usually during January through March, so that in many years young storks are still in the nests when summer rains begin.

Three important characteristics of Wood Stork reproductive dynamics in the post-project system are:

1) The timing of colony formation is influenced by the rate of drying in the central sloughs of the Everglades (Table 11).

2) Wood Stork colonies are relatively larger, and more often successful in years of relatively low water than in years of relatively high water in the Everglades, especially during the years of the Minimum Water Delivery schedule (Table 12).

3) The number of storks attempting to nest declined through time, and in almost no year since the mid-1970's has a high percentage of the total stork population in the park attempted to nest (Fig. 32).

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Table 11. Timing of Wood Stork colony formation, and number of nesting pairs, related to early dry season drying rates in the Southern Everglades, 1963-1990 (no nesting in 1961-1962).

Nesting Season	# Pairs	Nov-Jan Drying Rate P-33	Nov-Jan Drying Rate G-789	Month of Colony Formation
1962-63	1500	.0078	.0326	Dec
64	200	.0020	-.0063	Mar
65	2125	.0058	.0345	Dec
66	1450	.0036	.0300	Dec
67	2300	.0162	.0195	Dec
68	2800	.0052	.0243	Dec
69	1050	.0106	.0160	Dec
70	400	.0037	.0198	Jan
71	340	.0080	.0295	Jan
72	500	.0046	.0255	Feb
73	900	.0024	.0160	Feb
74	1000	.0057	.0113	Jan
75	1235	.0036	.0093	Jan
76	1225	.0018	.0286	Dec
77	650	.0021	.0113	Mar
78	0	.0048	.0043	--
79	1175	.0052	.0196	Jan
80	50	.0047	.0073	Mar
81	700	.0086	.0188	Mar
82	380	.0069	.0275	Feb
83	15	.0089	.0081	Dec
84	675	-.0013	.0085	Jan
85	445	.0059	.0025	Feb
86	375	.0055	.0000	Feb
87	150	.0054	.0000	Mar
88	220	.0051	.0075	Mar
89	515	.0120	N/D	Feb
90	150	.0063	N/D	Mar
	1558	.0075	.0242	Dec(8)
Means	830	.0052*	.0179	Jan(5)
1963-1983	593	.0046	.0230	Feb(3)
	400	.0044	.0124*	Mar(4)
	---	--	--	Dec (no formations)
Means	675	-.0013	.0085(1)	Jan(1)
1984-1990**	445	.0078	.0013(2)	Feb(3)
	173	.0056	.0038(2)	Mar(3)

Drying rates are expressed as the average daily change (feet per day) between the highest November and highest January water levels at two representative gauges (P-33 in north-central Shark Slough and G-789 in the upper Taylor Slough headwaters). *Excludes (-) values. **Experimental water delivery period within Shark Slough.

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Table 12. Water levels, number of nesting pairs and nesting success for Wood Storks in the Southern Everglades, 1963-1990 (no nesting in 1961-1962).

		Previous wet season high P-33	Previous wet season high G-789	No. Nesting Pairs	Success/ Failure
1962-63		6.20	5.95	1500	Succ.
64		6.30	5.93	200	Fail.
65		6.00	5.34	2125	Fail.
66		6.04	5.59	1450	Fail.
67		7.13	6.45	2300	Succ.
68		6.35	4.22	2800	Fail.
69		7.23	4.60	1050	Fail.
70		7.67	5.22	400	Fail.
71		7.05	4.76	340	Fail.
72		6.36	4.55	500	Fail.
73		6.51	5.05	900	Fail.
74		6.30	5.59	1000	Succ.
75		6.63	4.42	1235	Succ.
76		6.36	4.94	1225	Fail.
77		6.64	5.01	650	Fail.
78		6.46	5.17	0	Fail.
79		7.16	4.95	1175	Fail.
80		6.90	4.81	50	Fail.
81		6.95	4.75	700	Succ.
82		6.98	5.44	380	Fail.
83		7.59	4.65	15	Fail.
84		7.08	4.15	675	Fail.
85		7.01	4.27	445	Succ.
86		6.75	4.21	375	Fail.
87		6.76	3.92	150	Fail.
88		6.80	4.13	220	Fail.
89		7.21	N/D	515	Fail.
90		5.97	N/D	150	Fail.
Means	all years	6.70	5.24**	1197	Succ.(6)
	all years	6.73	4.83(20)	698	Fail. (22)
Means	1963-	6.64	5.43**	1347	Succ.(5)
	1983*	6.73	5.01	829	Fail. (16)

Water levels are for two representative gauges (P-33 in north-central Shark Slough and G-789 in the Taylor Slough headwaters). Success is defined as 50 percent or more of the potential nesting population attempting nesting, and an average of 1.0 chicks or more fledged per nesting attempt. *Prior to experimental delivery program. **Success continues to be associated with relatively high water conditions in the "short-hydroperiod" marshes; areas that are often dry in low water years.

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The Reasons for these Changing Relationships

The current understanding of the dynamics of Wood Stork reproductive ecology in the natural system strongly argues that relatively high water conditions were essential for early colony formation. For storks to start nesting in November or December meant that a strong food base must have been available during the early dry season, well before the deeper, central marshes of Shark Slough and Taylor Slough had dried sufficiently for utilization by feeding birds. The solution was for storks to feed in the relatively shorter hydroperiod wetlands located in the higher elevated marshes. These areas historically occurred along both flanks of the Shark Slough, along both flanks and across the headwaters of Taylor Slough, and throughout the Rocky Glades.

Wood Storks are long-distance flyers, and any good feeding habitat within 10 to 40 miles of the traditional colony sites is relatively easily reachable during a day. For these short-hydroperiod wetlands to be important as foraging habitat for storks during the November through January period they must be shallowly flooded during those months, and be hydrologically connected during high water periods each year with the highly productive core areas of deeper sloughs. Thus, high water years flooded these short hydroperiod marshes more extensively, allowing for early (normal) colony formations (Fig. 33). In high water years, the relatively large areas of shallow water feeding habitat created early in the dry season meant that drying rates, *per se*, were relatively unimportant as a mechanism for stimulating storks to nest, since rapid drying was not needed to create extensive feeding conditions early in the nesting season.

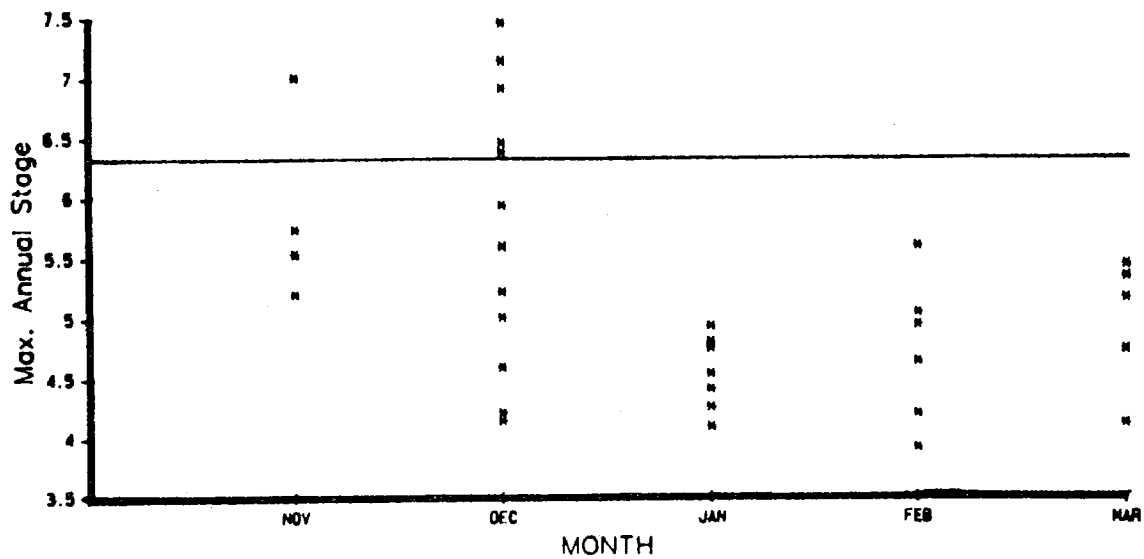

Figure 33. Relationship between maximum annual stage at G789 (in the headwaters of Taylor Slough) and timing of wood stork colony formations, 1953-1987.

The contrast between the natural conditions and the more recent, post-project conditions is substantial. Past water management has shortened hydroperiods and vastly lowered water levels throughout the eastern portion of the Everglades ecosystem (Fig. 34). This has resulted in elimination of much of the short-hydroperiod wetlands as important feeding habitat and has changed the timing of drying relative to nesting patterns (Ogden, Loftus, and Robertson 1988). Regionally, storks are now forced to depend on the deeper sloughs and impoundments as the most reliable feeding sites in the Southern Everglades. Because the deeper sloughs and

impoundments only become shallow enough to support storks late in the dry season (February through May), storks now delay nesting to coincide with the availability of this food resource. Thus, the more rapid and extensive that drying occurs regionally, the earlier these deeper water sites become available for feeding by potential breeders.

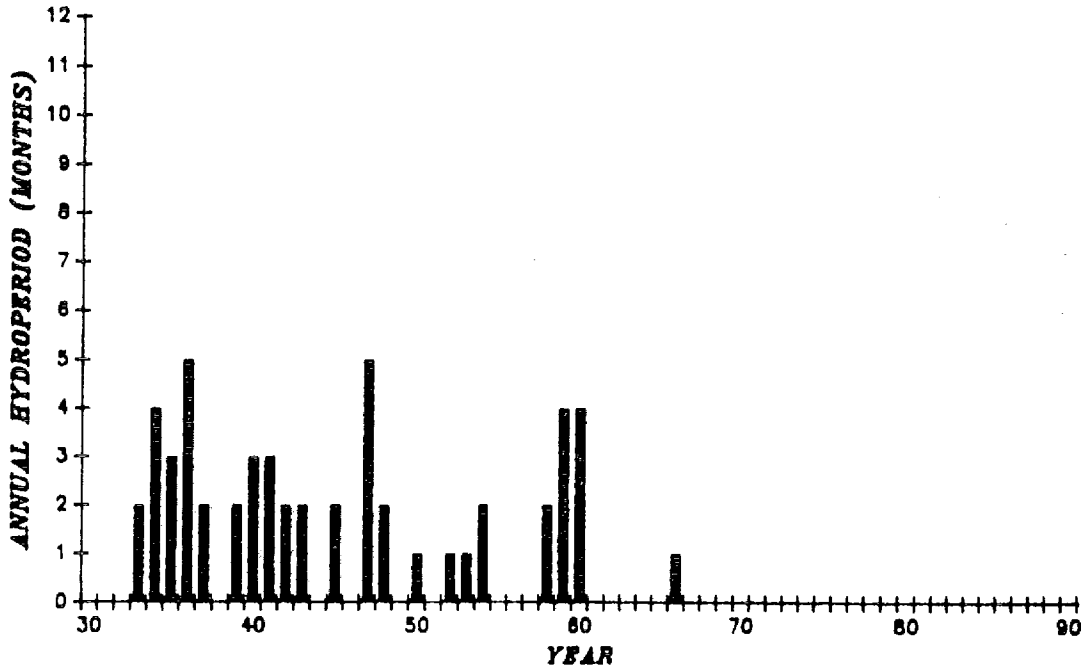

Figure 34. Estimated annual hydroperiod for station G789. Based on actual monthly data from 1/1956 through 2/1990, and estimated monthly data from 10/1932 through 12/1955. (Calculated using a least squares linear regression for the period from 1/1956 through 4/1964, based on monthly average water levels at station S196A, adjusted R^2 = 0.951, N = 94, F sign. = 0.000).

The shift by storks from using the early-drying, short-hydroperiod wetlands as a trigger to initiate nesting, to later-drying central sloughs and impoundments, is the primary explanation for the stork's rapid decline in the Everglades. Changes in the system and the associated delay in nesting has severely stressed the Everglades stork population in two important ways:

1) Greatly shortened hydroperiods in higher elevated wetlands, and the increased frequency of low-water conditions in the deeper central marsh areas of lower Shark Slough and Taylor Slough, appear to be causing a chronic deterioration in the biological vitality of the entire system (Fig. 35). Thus, with a reduced food base, water levels must be lower now than in the past, for comparable fish concentrations to be created. One indication that such a deterioration in the food base for Wood Storks has been occurring can be seen by comparing the reproductive effort by storks between the 1970's and 1980's, for years with generally similar drying rates (Table 11). In the 1980's, relatively high drying rates have not produced the level of nesting effort by storks that resulted from similar drying rates during the 1970's.

2) Delayed initiation of stork nesting is correlated with reduced reproductive effort (fewer pairs attempting to breed) and with a reduced rate of nesting success (Fig. 36). Although the correlation between timing and numbers of pairs in colonies is not well understood, NPS survey data suggest that the number of adult storks may peak by

January, then, in the absence of suitable nesting conditions, birds begin to move north. Available evidence suggests that when relatively low numbers of storks nest in south Florida, relatively high numbers will nest in central and north Florida (Ogden et al. 1987).

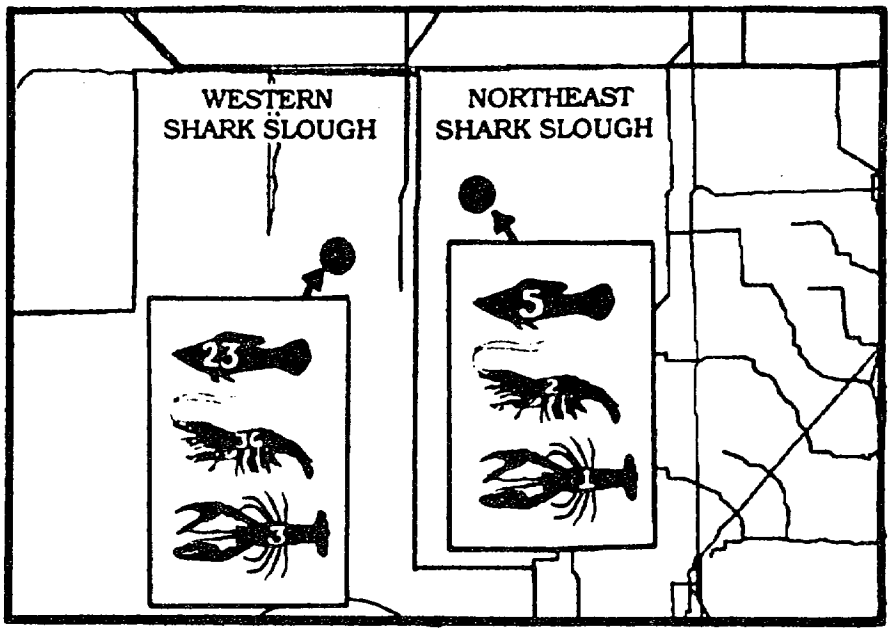

Figure 35. Grand mean per square meter for fishes, prawns, and crayfish (based on sampling between October 1985 and October 1986).

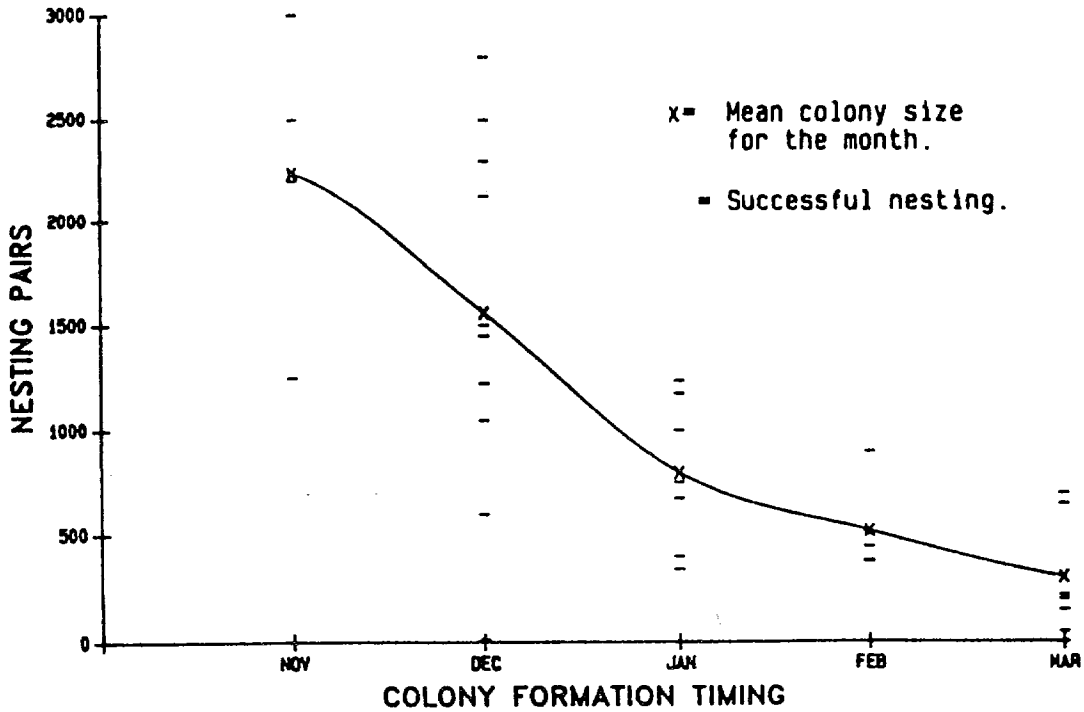

Figure 36. Relationship between Wood Stork colony size and timing of colony formation, Everglades National Park, 1955-1990.

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The reduced success rate associated with late colony formation is better understood. Although several factors may operate to reduce success rates (the timing of winter rain storms relative to the timing of nesting, for example), late fledging of chicks (May through July) is one factor that clearly causes major problems for the population. The May through July period usually is a hostile environment for storks in south Florida in one of two ways:

a) The late dry season, especially in low water years or in years of delayed summer rains, often finds much of the interior marshes dry, with few good feeding habitats remaining. Under such conditions, adult storks, hard-pressed to locate food, have been recorded flying up to 80 miles from colonies to feed. The inevitable result is fewer feedings and increased rates of nestling mortality.

b) Conditions for nestling storks become even more dismal if summer rains return at normal or above-normal rates by late May or June. Rapidly rising water quickly disperses the remaining food base, and adult storks usually are unable to obtain enough fish to rear healthy chicks.

Assessment of the Four Proposed Alternatives related to Wood Storks

Recovery of the Everglades population of Wood Storks will require a general increase in the biological vitality of the system, including a significant increase in hydroperiods and areas of seasonal inundation within a framework of natural patterns of water distribution and surface water flows. Specifically, two objectives must be met:

1) Colony formation must occur early in the dry season, between November and January in most years, in order for the nesting cycle to be completed prior to the next rainy season. This also allows the nestlings to be fed during the period between March and May, when maximum food resources are most often available.

2) Larger numbers of Wood Storks than in most years since the mid-1970's must attempt to nest. The ideal nesting number should be a large percentage of the potential nesting population for south Florida (perhaps developed by a study of the adult/immature ratio of the "wintering" population of storks in the Everglades).

These two objectives can only be achieved if hydroperiods and areas of inundation, particularly in the remaining short-hydroperiod wetlands, can be significantly increased. This should be accomplished in such a way that natural surface water distribution patterns are re-established throughout the foraging range of the traditional stork colony sites. This restoration of more natural hydrologic conditions is needed to synchronize feeding habitat conditions with the timing of the traditional, and historically more successful, November through April stork nesting period.

The four proposed alternatives do not appear to significantly increase the total area of surface water inundation within the Southern Everglades region. The two rain-driven alternatives, however, showed the greatest increases in water depths, total areas of inundations, and were the most successful at increasing the amount of short hydroperiod habitat, particularly in the early dry season. These alternatives also re-established more natural flow patterns along the historical eastern flow-way of WCA 3B and NESS, and provided more persistent flows down the central core of lower Shark Slough and into the downstream headwaters. They also maintained the longest hydroperiods in the higher marshes of the Rocky Glades. The Base and

Modified Base alternatives held too much surface water within the artificial impoundment of WCA 3A reducing the value of these wetlands as foraging habitat, and failed to adequately re-inundate the deeper core habitat in Northeast Shark Slough.

Improvements to the existing Rainfall-Driven delivery formula, coupled with the structural changes associated with the rain-driven alternatives, represent the management approach that is most likely to re-establish more natural timing and distribution patterns for surface water in the park and in adjacent wetlands. It will be these hydrological improvements, and especially the recovery of the core wetlands and re-establishment of longer hydroperiods in the higher elevated marshes, that must occur if the Southern Everglades population of Wood Storks is to recover.

POTENTIAL IMPACTS OF THE FOUR ALTERNATIVES ON SNAIL KITES

Approximately 40 percent of the study area has been designated as critical habitat for the Snail Kite. For this reason, an analysis was conducted by the National Park Service to determine the impacts of the proposed alternatives on present Snail Kite occupancy within the area. In particular, the analysis focused on predicted changes in Snail Kite temporal dispersal patterns from WCA 3A, and estimated dispersal-related relative mortality as affected by annual, drydown characteristics for the four proposed alternatives. Predicted changes in the quantity and quality of long-term, core habitat for the Snail Kite in WCA 3A were also compared among the proposed alternatives.

A separate assessment for the Snail Kite was more recently conducted by the National Park Service using hydrological parameters associated with the Snail Kite's nesting ecology. These parameters were proposed by Snail Kite experts James Rodgers, Robert Bennetts and Steve Beissinger during meetings at Everglades National Park in May 1990. All three biologists expressed concern that empirical data on Snail Kite dispersal and on related mortality were insufficient for direct evaluation of the potential impacts of the four alternatives. They suggested that empirical data do exist, however, to show that Snail Kite nesting success is related to water depth and duration of flooding at kite nesting sites and adjacent foraging areas.

Documentation of the results of these analyses for each alternative are provided in the tables and figures referenced within this section of the report. However, this section will only review the comparison of Base *vs* the Basic Rain-Driven alternative, the alternative initially developed by the COE, the SFWMD, and the NPS to address the needed restoration goals for Everglades National Park.

Drydown Characteristics under the Base and Basic Rain-Driven Alternatives

A comparison of monthly surface water distribution estimates for WCA 3A for each year of the evaluation period for the proposed water delivery alternatives, and the descriptive statistics for the monthly means of these estimates over the 14-year evaluation period, are presented in Tables 13 and 14. Surface water conditions within WCA 3A under the Base alternative had higher average dry season recession rates than under the Basic Rain-Driven alternative. This higher recession rate resulted in an earlier and increased duration of drying over a larger area of designated Snail Kite critical habitat within WCA 3A compared to the drydown characteristics of the Basic Rain-Driven alternative.

Table 13. Percentage of Water Conservation Area 3A cells with surface water during the dry season months under the four proposed alternatives.

		DEC	JAN	FEB	MAR	APR	MAY
BASE	AVERAGE	99.7	94.9	85.9	60.0	45.6	54.8
	ST. DEV.	0.6	5.9	12.7	29.8	37.7	36.1
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	98.4	78.9	66.7	25.2	4.9	3.3
	RANGE	1.6	21.2	33.3	74.8	95.1	96.8
MOD. BASE	AVERAGE	99.7	95.9	90.0	73.3	53.6	57.8
	ST. DEV.	0.6	4.6	9.5	22.7	35.5	35.9
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	98.4	84.6	74.8	35.0	14.6	3.3
	RANGE	1.6	15.5	25.2	65.0	85.4	96.8
BASIC RAIN	AVERAGE	99.8	96.6	91.5	78.0	55.4	56.2
	ST. DEV	0.4	3.6	7.9	18.7	35.7	39.5
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	99.2	88.6	77.2	45.5	7.3	0.0
	RANGE	0.8	11.4	22.8	54.5	92.7	100.0
MOD. RAIN	AVERAGE	99.8	96.2	90.5	79.3	61.9	61.1
	ST. DEV	0.3	3.8	8.9	16.9	29.8	35.1
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	99.2	90.3	76.4	54.5	26.8	0.8
	RANGE	0.8	9.8	23.6	45.5	73.2	99.2

Table 14. Percentage of Water Conservation Area 3A cells with surface water during the wet season months under the four proposed alternatives.

		JUN	JUL	AUG	SEP	OCT	NOV
BASE	AVERAGE	87.1	92.9	99.8	100.0	99.9	100.0
	ST. DEV.	23.3	16.8	0.5	0.0	0.2	0.0
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	14.6	35.8	98.4	100.0	99.2	100.0
	RANGE	85.4	64.2	1.6	0.0	0.8	0.0
MOD. BASE	AVERAGE	89.0	94.3	100.0	100.0	100.0	100.0
	ST. DEV.	20.5	14.0	0.0	0.0	0.0	0.0
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	22.0	46.3	100.0	100.0	100.0	100.0
	RANGE	78.1	53.7	0.0	0.0	0.0	0.0
BASIC RAIN	AVERAGE	87.1	92.9	99.5	99.8	99.9	100.0
	ST. DEV	23.9	13.1	1.0	0.6	0.2	0.0
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	4.9	49.6	97.6	97.6	99.2	100.0
	RANGE	95.1	50.4	2.5	2.5	0.8	0.0
MOD. RAIN	AVERAGE	89.9	96.1	100.0	100.0	100.0	100.0
	ST. DEV	19.5	9.2	0.0	0.0	0.0	0.0
	MAXIMUM	100.0	100.0	100.0	100.0	100.0	100.0
	MINIMUM	25.2	65.0	100.0	100.0	100.0	100.0
	RANGE	74.8	35.0	0.0	0.0	0.0	0.0

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The number of annual and cumulative drydown occurrences and the average drydown intervals by selected drydown percentile classes for the Base and Basic Rain-Driven alternatives are presented in Table 15. Average drydown intervals for both alternatives were the same for cumulative drydown occurrences under which 15 percent or less of WCA 3A retained surface water at the end of a seasonal drydown (once every 2.8 years). The average interval for complete drydowns for the Basic Rain-Driven alternative averaged once in every seven years and once in every 4.7 and 3.5 years for 1-5 and 6-10 cumulative percentile drydown classes, respectively. The average drydown intervals for these cumulative percentile drydown classes for both the Basic Rain-Driven and Base alternatives were above the minimum average drydown intervals required to maintain stable and productive Apple Snail populations upon which Snail Kites depend. The number of drydown occurrences in the higher cumulative percentile classes was greater for the Base alternative.

Table 15. Comparison of the number of annual dry-downs and average drydown intervals (in years) by five percentile drydown classes for the Base and Basic Rain-Driven alternatives.

Drydown Class (% area inundated)	BASE # Annual Occurrences Per Class	BASE # Annual Occurrences Cumulative	BASE Avg. Freq. (yrs)	BASIC RAIN-DRIVEN # Annual Occurrences Per Class	BASIC RAIN-DRIVEN # Annual Occurrences Cumulative	BASIC RAIN-DRIVEN Avg. Freq. (yrs)
0	0	0	N/A	2	2	7.0
1 - 5	2	2	7.0	1	3	4.7
6 - 10	0	2	7.0	1	4	3.4
11 - 15	3	5	2.8	0	5	2.8
16 - 20	2	7	2.0	0	5	2.8
21 - 25	1	8	1.8	0	5	2.8
26 - 30	0	8	1.8	0	5	2.8
31 - 35	0	8	1.8	2	7	2.0
36 - 40	0	8	1.8	0	7	2.0
41 - 45	1	9	1.6	0	7	2.0
46 - 50	0	9	1.6	1	8	1.8
51 - 55	0	9	1.6	0	8	1.8
56 - 60	0	9	1.6	0	8	1.8
61 - 65	0	9	1.6	0	8	1.8
66 - 70	0	9	1.6	0	8	1.8
71 - 75	1	10	1.4	1	9	1.6
76 - 80	0	10	1.4	1	10	1.4
81 - 85	1	11	1.3	1	11	1.3
86 - 90	1	12	1.2	0	11	1.3
91 - 95	1	13	1.1	1	12	1.2
96 - 99	0	13	1.1	1	13	1.1
100	1	14	1.0	1	14	1.0

The monthly Snail Kite dispersal sighting data reported by Takekawa and Beissinger (1989), and the empirical estimates of monthly surface water area for the 1985 drydown in WCA 3A are presented in Figures 37 and 38. The revised Snail Kite regression "dispersal curve" developed from those data sets is depicted in Figure 39. More than five percent of the total area of WCA 3A remained wet during 1985 when the Snail Kite dispersal sighting data were collected.

Because surface water area estimates of less than five percent occur for both the Base and Basic Rain-Driven alternatives during the 14 year evaluation period, the dispersal curve was adjusted upward for this range of surface water area to approximate more accurately the rates of increase indexed by the empirical kite dispersal sighting data.

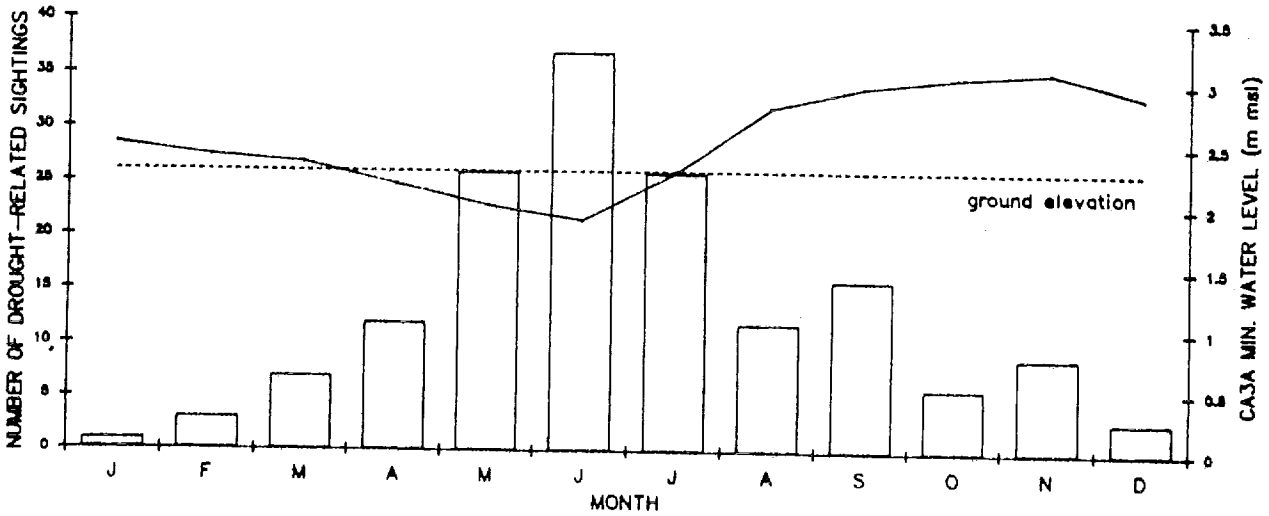

Figure 37. Monthly Snail Kite dispersal sightings in relation to month and water level, June-December 1985 (from Takekawa and Beissinger, 1989).

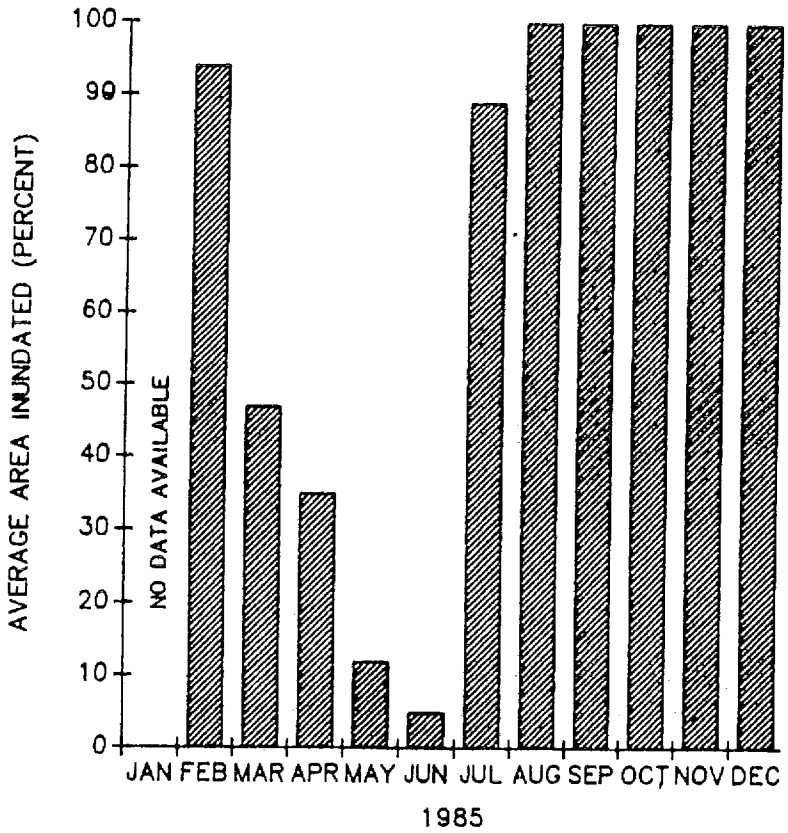

Figure 38. Empirical estimates of percent surface water area in WCA 3A for January-December 1985 (NPS unpublished data).

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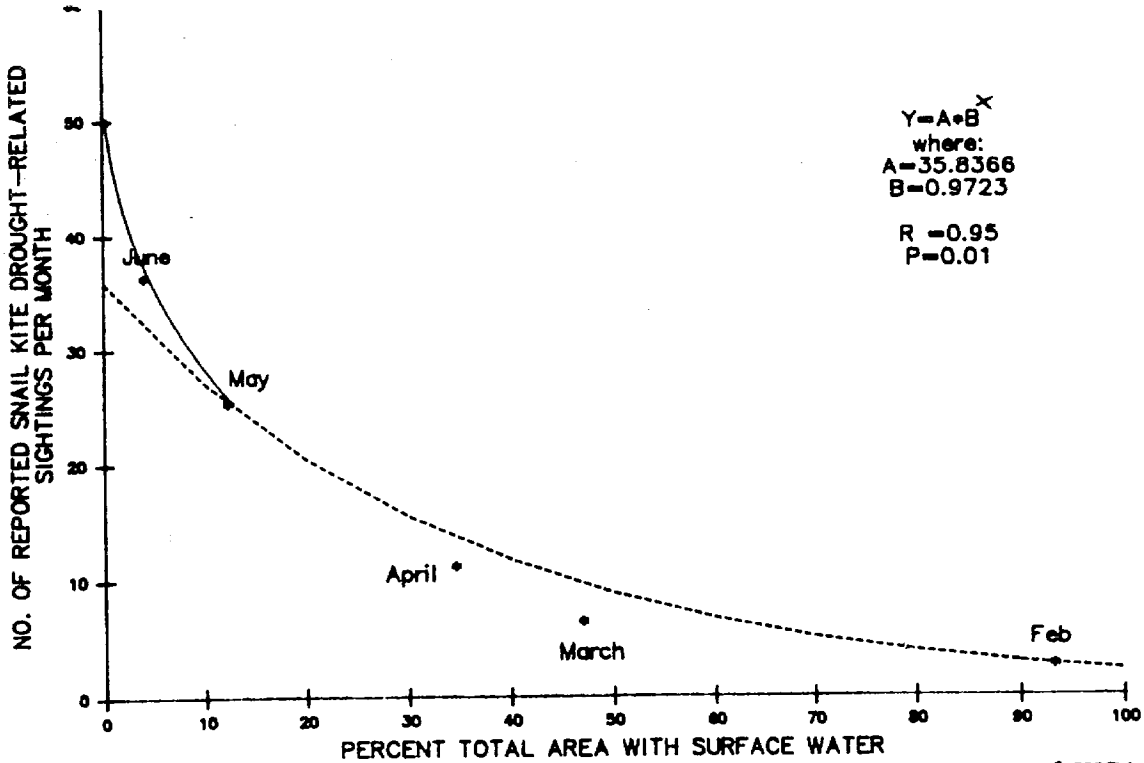


Figure 39. Relationship between Snail Kite dispersal tendency to proportion of WCA 3A with surface water, February-June 1985.

The number of Snail Kite dispersal sightings predicted from this curve for each dry season month of the evaluation period are listed in Table 16. The resultant hypothetical, sample populations of dispersed kites, calculated with an initial no mortality assumption are presented in Table 17. The predicted Snail Kite temporal dispersal patterns for Base and Basic Rain-Driven alternatives reflected the differences in drydown characteristic between the two alternatives. The higher recession rates, and resultant earlier drying of the basin characteristic of the Base alternative, consistently dispersed a greater proportion of Snail Kites earlier in the dry season each year from WCA 3A than that predicted for the Basic Rain-Driven alternative. Under the Base alternative, Snail Kites were dispersed for a longer period on the average each year. This pattern of earlier dispersal of Snail Kites under the Base alternative was particularly true for the driest or most drought-prone years of the evaluation period. Empirical data from the SRF aerial surveys over the WCAs, for 1985 and 1989-1990, confirmed that most kites depart WCA 3A by the time the drying pool has been reduced to 20 - 30 percent of the total surface area (M. Fleming, W. Hoffman, pers. com.).

The predicted dispersal-related Snail Kite relative mortality estimates calculated for each of the hypothetical mortality models are presented in Table 18. The earlier dispersal of a greater proportion of the modeled population of dispersed kites, as characteristic of the Base alternative, resulted in greater predicted Snail Kite annual, relative mortality estimates for the Base alternative during the 14-year evaluation period. Resultant average annual and 14-year average dispersal-related relative mortality estimates were also higher over the evaluation period under the Base alternative for all of the different mortality-model runs. Although dispersal-related relative mortality estimates under the Base alternative were frequently higher than under the Basic Rain-Driven alternative, the differences in the relative mortality estimates between the two alternatives were not significant.

Table 16. Predicted number of dry season dispersed Snail Kite sightings under the four proposed alternatives.

ALTERN	YEAR	DEC	JAN	FEB	MAR	APR	MAY	SUM
BASE	69	2	2	2	2	2	3	13
MOD. BASE	69	2	2	2	2	2	2	12
RAIN	69	2	2	2	2	2	3	13
MOD. RAIN	69	2	2	2	2	2	3	13
BASE	70	2	2	2	2	2	2	12
MOD. BASE	70	2	2	2	2	2	2	12
RAIN	70	2	2	2	2	2	2	12
MOD. RAIN	70	2	2	2	2	2	2	12
BASE	71	2	3	6	18	24	23	76
MOD. BASE	71	2	3	4	13	24	21	67
RAIN	71	2	3	4	10	32	32	83
MOD. RAIN	71	2	3	4	8	15	23	55
BASE	72	2	2	2	3	4	2	15
MOD. BASE	72	2	2	2	2	2	2	12
RAIN	72	2	2	2	2	2	2	12
MOD. RAIN	72	2	2	2	2	2	2	12
BASE	73	2	3	5	13	33	40	96
MOD. BASE	73	2	3	4	6	23	40	78
RAIN	73	2	2	3	5	17	50	79
MOD. RAIN	73	2	3	4	5	13	49	76
BASE	74	2	2	5	16	24	22	71
MOD. BASE	74	2	2	4	7	20	30	65
RAIN	74	2	2	3	6	20	50	83
MOD. RAIN	74	2	2	4	7	15	32	62
BASE	75	2	3	5	16	20	16	62
MOD. BASE	75	2	3	4	13	19	15	56
RAIN	75	2	3	4	10	28	18	65
MOD. RAIN	75	2	3	4	7	14	10	40
BASE	76	2	3	3	13	23	2	46
MOD. BASE	76	2	3	3	6	15	2	31
RAIN	76	2	2	3	5	14	2	28
MOD. RAIN	76	2	3	3	5	9	2	24
BASE	77	2	2	2	9	19	15	49
MOD. BASE	77	2	2	2	6	17	11	40
RAIN	77	2	2	2	5	14	8	33
MOD. RAIN	77	2	2	2	5	11	8	30
BASE	78	2	2	2	3	8	10	27
MOD. BASE	78	2	2	2	3	5	6	20
RAIN	78	2	2	2	2	4	5	17
MOD. RAIN	78	2	2	2	2	4	4	16
BASE	79	2	2	2	3	3	4	16
MOD. BASE	79	2	2	2	2	2	3	13
RAIN	79	2	2	2	3	0	3	12
MOD. RAIN	79	2	2	2	3	0	3	12
BASE	80	2	2	2	2	2	3	13
MOD. BASE	80	2	2	2	2	2	3	13
RAIN	80	2	2	2	2	2	3	13
MOD. RAIN	80	2	2	2	2	2	3	13
BASE	81	2	4	4	16	37	37	100
MOD. BASE	81	2	3	3	8	17	23	56
RAIN	81	2	3	3	5	17	45	75
MOD. RAIN	81	2	3	3	5	9	16	38
BASE	82	2	3	4	10	22	7	48
MOD. BASE	82	2	3	3	4	15	6	33
RAIN	82	2	3	3	4	9	6	27
MOD. RAIN	82	2	3	4	6	17	6	38

Table 17. Hypothetical sample populations of dispersed Snail Kites under the four proposed alternatives.

ALTERN	YEAR	DEC	JAN	FEB	MAR	APR	MAY	SUM
BASE	69	2	0	0	0	0	1	3
MOD. BASE	69	2	0	0	0	0	0	2
RAIN	69	2	0	0	0	0	1	3
MOD. RAIN	69	2	0	0	0	0	1	3
BASE	70	2	0	0	0	0	0	2
MOD. BASE	70	2	0	0	0	0	0	2
RAIN	70	2	0	0	0	0	0	2
MOD. RAIN	70	2	0	0	0	0	0	2
BASE	71	2	1	3	12	6	0	24
MOD. BASE	71	2	1	1	9	11	0	24
RAIN	71	2	1	1	6	22	0	32
MOD. RAIN	71	2	1	1	4	7	8	23
BASE	72	2	0	0	1	1	0	4
MOD. BASE	72	2	0	0	0	0	0	2
RAIN	72	2	0	0	0	0	0	2
MOD. RAIN	72	2	0	0	0	0	0	2
BASE	73	2	1	2	8	20	7	40
MOD. BASE	73	2	1	1	2	17	17	40
RAIN	73	2	0	1	2	12	33	50
MOD. RAIN	73	2	1	1	1	8	36	49
BASE	74	2	0	3	11	8	0	24
MOD. BASE	74	2	0	2	3	13	10	30
RAIN	74	2	0	1	3	14	30	50
MOD. RAIN	74	2	0	2	3	8	17	32
BASE	75	2	1	2	11	4	0	20
MOD. BASE	75	2	1	1	9	6	0	19
RAIN	75	2	1	1	6	18	0	28
MOD. RAIN	75	2	1	1	3	7	0	14
BASE	76	2	1	0	10	10	0	23
MOD. BASE	76	2	1	0	3	9	0	15
RAIN	76	2	0	1	2	9	0	14
MOD. RAIN	76	2	1	0	2	4	0	9
BASE	77	2	0	0	7	10	0	19
MOD. BASE	77	2	0	0	4	11	0	17
RAIN	77	2	0	0	3	9	0	14
MOD. RAIN	77	2	0	0	3	6	0	11
BASE	78	2	0	0	1	5	2	10
MOD. BASE	78	2	0	0	1	2	1	6
RAIN	78	2	0	0	0	2	1	5
MOD. RAIN	78	2	0	0	0	2	0	4
BASE	79	2	0	0	1	0	1	4
MOD. BASE	79	2	0	0	0	0	1	3
RAIN	79	2	0	0	1	0	3	6
MOD. RAIN	79	2	0	0	1	0	3	6
BASE	80	2	0	0	0	0	1	3
MOD. BASE	80	2	0	0	0	0	1	3
RAIN	80	2	0	0	0	0	1	3
MOD. RAIN	80	2	0	0	0	0	1	3
BASE	81	2	2	0	12	21	0	37
MOD. BASE	81	2	1	0	5	9	6	23
RAIN	81	2	1	0	2	12	28	45
MOD. RAIN	81	2	1	0	2	4	7	16
BASE	82	2	1	1	6	12	0	22
MOD. BASE	82	2	1	0	1	11	0	15
RAIN	82	2	1	0	1	5	0	9
MOD. RAIN	82	2	1	1	2	11	0	17

Table 18. A comparison of predicted Snail Kite dispersal-related relative mortality estimates over the 14 year evaluation period for the proposed water delivery alternatives.

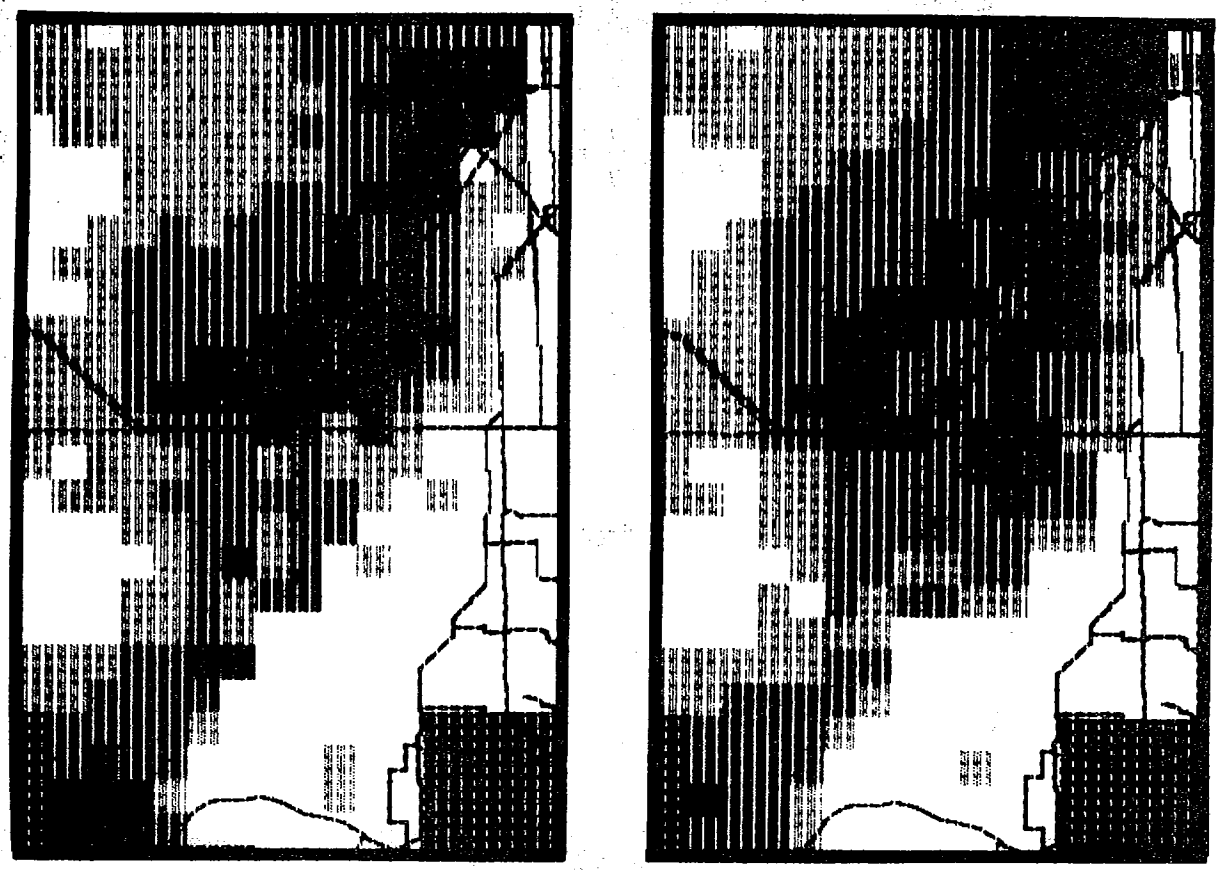
Mortality Model Type	Relative Mortality Parameter	Predicted, Dispersal-related Relative Mortality Estimates/Alternatives			
		Base (%)	Mod. Base (%)	Rain (%)	Mod. Rain (%)
Type I constant	avg. annual	29.6	30.4	27.7	28.9
	14 year avg.	26.0	23.8	20.1	21.7
Type II Constant	avg. annual	29.6	30.4	27.7	28.9
	14 year avg.	26.0	23.8	20.1	21.7
Type I Increasing	avg. annual	58.6	59.3	53.8	55.9
	14 year avg.	53.0	47.7	39.7	42.7
Type II Increasing	avg. annual	70.1	69.7	65.3	66.7
	14 year avg.	67.3	62.4	55.5	57.3
Type I Dec./Inc.	avg. annual	26.3	31.2	28.6	29.9
	14 year avg.	16.5	17.4	15.1	17.5
Type II Dec./Inc.	avg. annual	46.7	46.9	46.1	46.3
	14 year avg.	45.9	45.2	43.9	44.2

Assessment of the Potential Impacts on Snail Kite Suitable Habitat

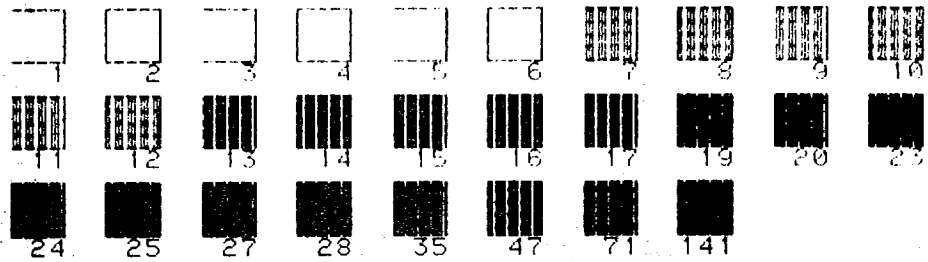
The location and areal extent of the average drydown intervals within the study area under the four proposed alternative are shown in Figure 40A and 40B. The proportions of WCA 3A that met the average drydown interval requirements for long-term Snail Kite prey habitat and suitable nesting habitat (core habitat conditions) were also mapped using the park's GIS system. The areal extent and location of Snail Kite core habitat maintained over the evaluation period are depicted for the four proposed alternatives in Figure 41.

The proportions of WCA 3A maintained as Snail Kite prey habitat, suitable nesting habitat, and core habitat over the 14-year evaluation period for the Base and Basic Rain-Driven alternatives are presented in Figure 42. The Basic Rain-Driven alternative maintained approximately 15 percent more Snail Kite prey habitat, 8 percent more suitable nesting habitat, and 20 percent more core habitat in WCA 3A over the 14-year evaluation period compared to the Base alternative. Over half (53 percent) of the area of WCA 3A was maintained as Snail Kite core habitat with the Basic Rain-Driven alternative compared to less than one third (31 percent) of the area remaining as core habitat over the evaluation period under the Base alternative.

The distribution of average drydown intervals in WCA 3A under the Base alternative for the evaluation period was more highly skewed to lower drydown interval ranges compared to the Basic Rain-Driven alternative (Fig. 43). In addition to maintaining a significantly greater area of Snail Kite core or primary habitat in WCA 3A, the Basic Rain-Driven alternative also maintained a greater area of secondary Snail Kite habitat within WCA 3A over the evaluation period, compared to the Base alternative.



A B



1 0.0 year	9 0.8 year	17 1.6 year	35 3.4 year
2 0.1 year	10 0.9 year	19 1.8 year	47 4.6 year
3 0.2 year	11 1.0 year	20 1.9 year	71 7.0 year
4 0.3 year	12 1.1 year	23 2.2 year	141 14.0 year
5 0.4 year	13 1.2 year	24 2.3 year	
6 0.5 year	14 1.3 year	25 2.4 year	
7 0.6 year	15 1.4 year	27 2.6 year	
8 0.7 year	16 1.5 year	28 2.7 year	

Figure 40A. Distribution of average drydown intervals (years) for (A) Base and (B) Modified Base alternatives.

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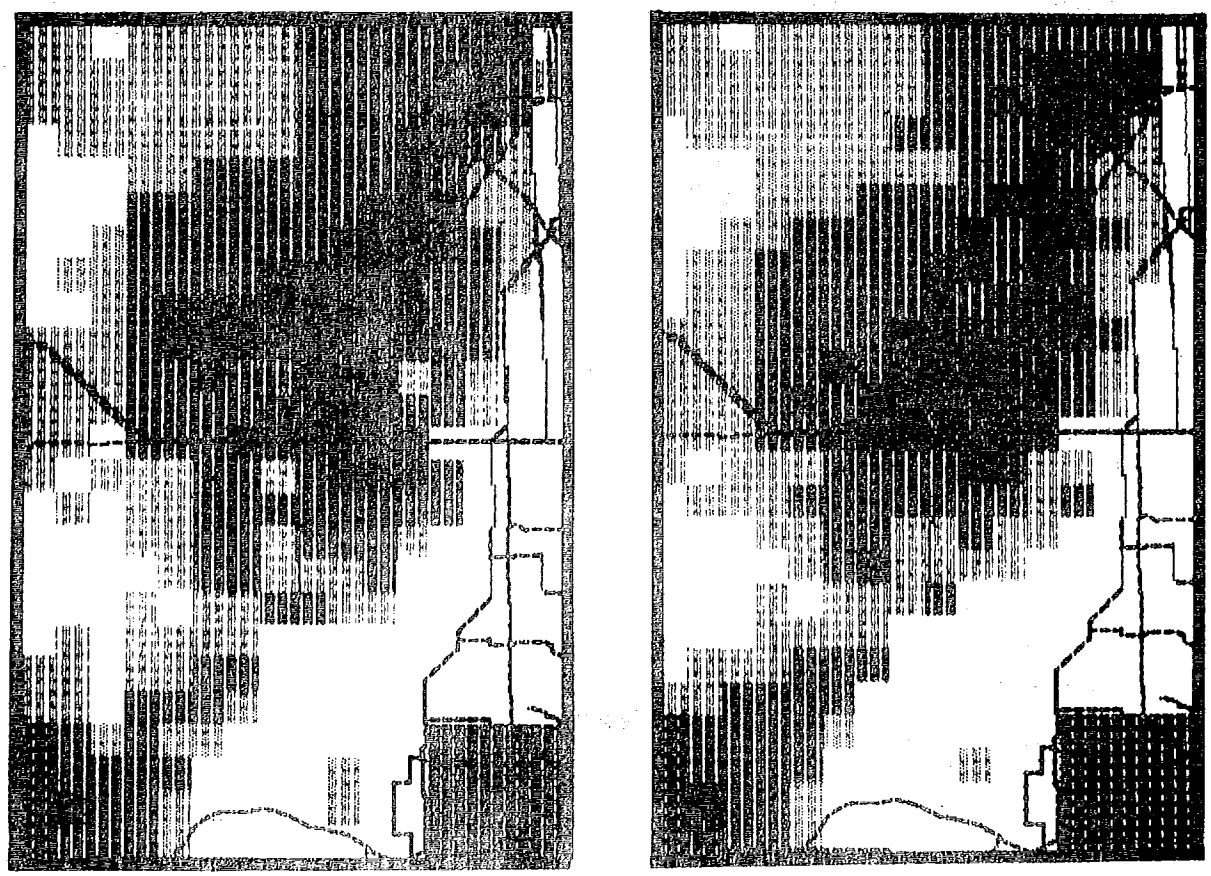
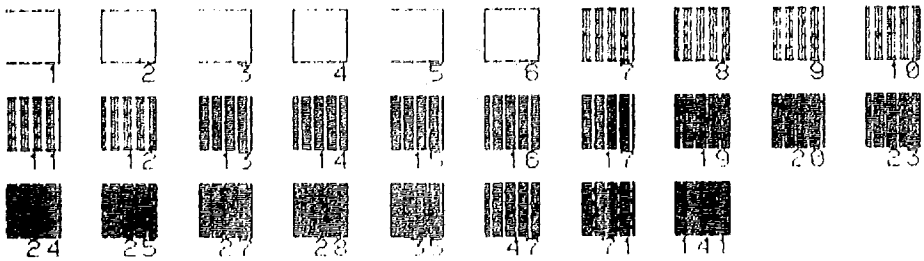


A B



1 0.0 year	9 0.8 year	17 1.6 year	35 3.4 year
2 0.1 year	10 0.9 year	19 1.8 year	47 4.6 year
3 0.2 year	11 1.0 year	20 1.9 year	71 7.0 year
4 0.3 year	12 1.1 year	23 2.2 year	141 14.0 year
5 0.4 year	13 1.2 year	24 2.3 year	
6 0.5 year	14 1.3 year	25 2.4 year	
7 0.6 year	15 1.4 year	27 2.6 year	
8 0.7 year	16 1.5 year	28 2.7 year	

Figure 40B. Distribution of average drydown intervals (years) for (A) Basic Rain-Driven and (B) Modified Rain-Driven alternatives.

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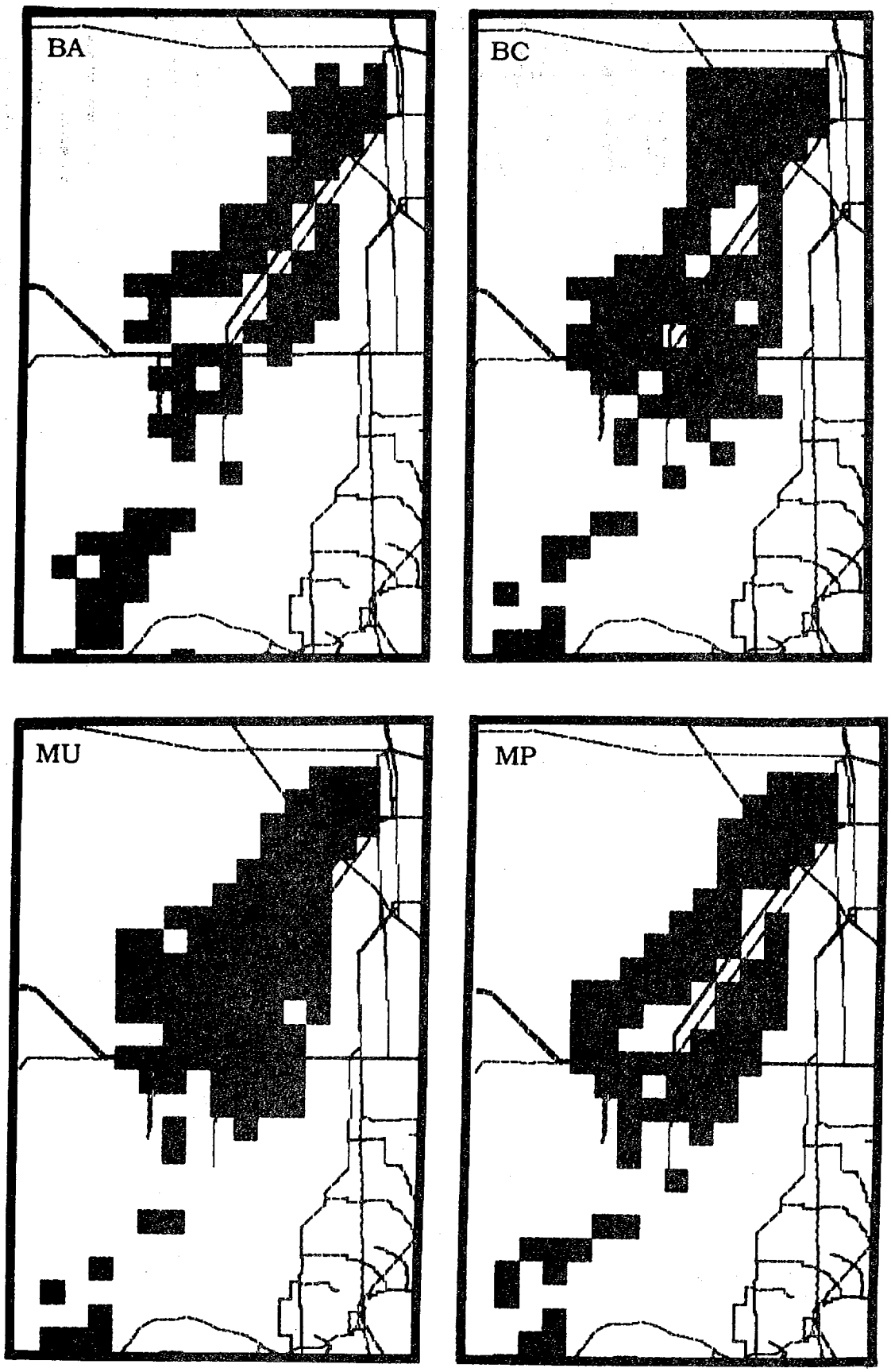

Figure 41. Long-term suitable habitat for the Snail Kite mainained under the four proposed alternatives; Base (BA), Modified Base (BC), Basic Rain-Driven (MU), and Modified Rain-Driven (MP).

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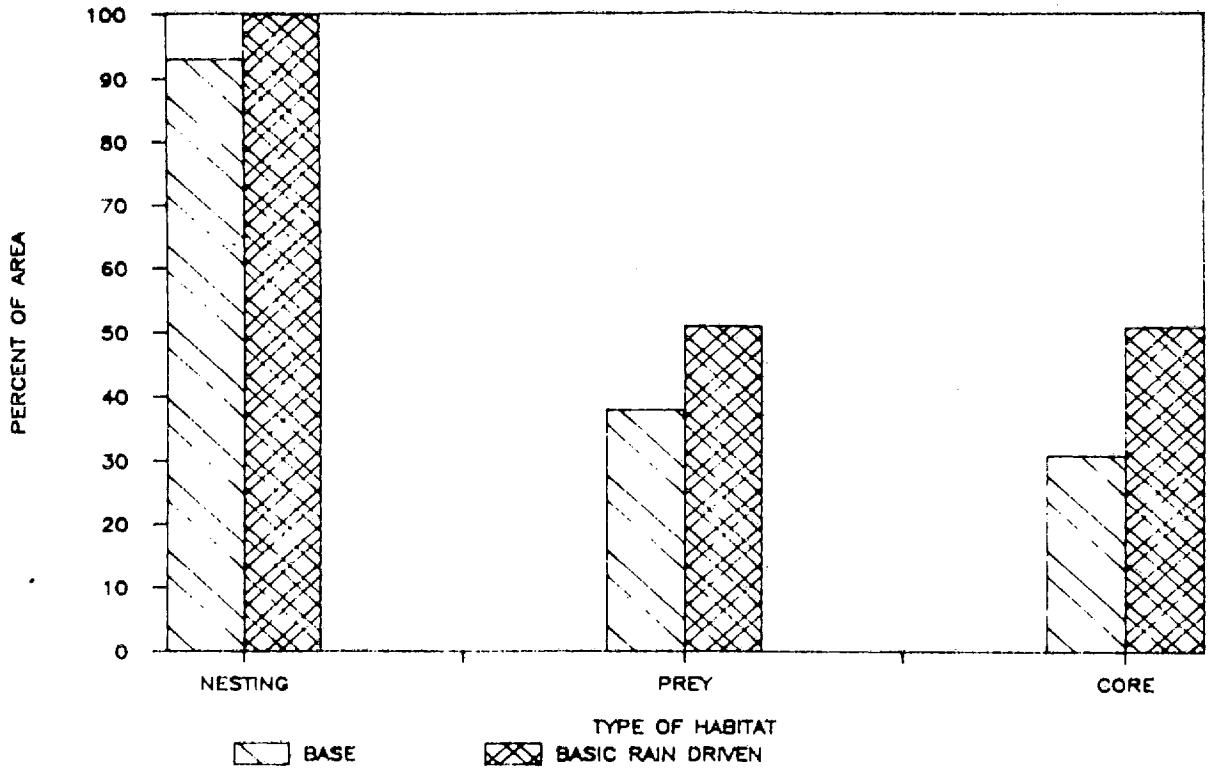

Figure 42. Percent of WCA 3A maintained as Snail Kite pre habitat, suitable nesting habitat, and core habitat calculated over the 14-year evaluation period for Base vs. the Basic Rain-Driven alternative.

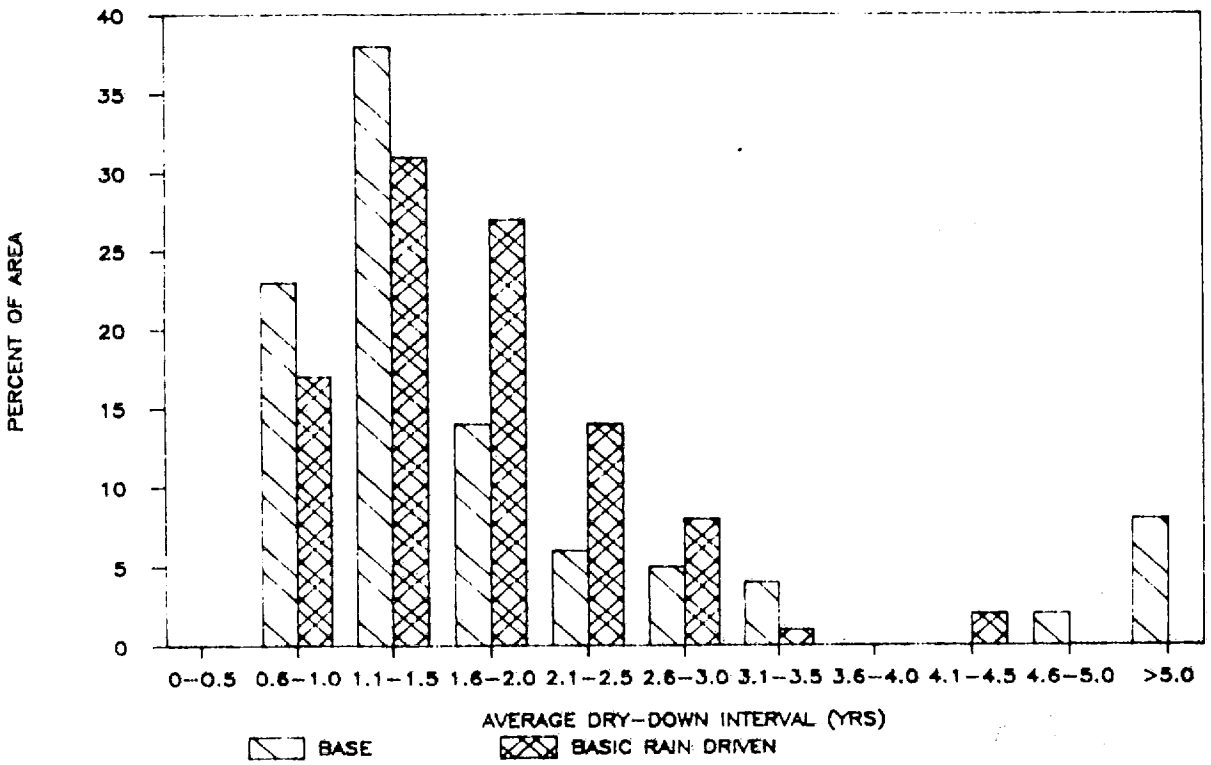

Figure 43. Percent of WCA 3A in each average drydown interval class calculated over the 14-year evaluation period for Base vs. the Basic Rain-Driven alternative.

Under the Base alternative, the area of Snail Kite core habitat in WCA 3A and adjacent basins was fragmented due to excessively high stage durations that were maintained in the downstream portions of the basin. Under the Basic Rain-Driven alternative, no fragmentation of core habitat occurred within the basin or adjoining marsh areas. The Base alternative also resulted in a greater proportion of Snail Kite critical habitat within WCA 3A being maintained in extreme ranges of the average drydown intervals, compared to the Basic Rain-Driven alternative. These areas of extreme average drydown intervals within the impoundment exceeded the upper and lower limits of average drydown intervals required to maintain long-term Snail Kite suitable habitat.

Assessment of the Potential Impacts on Snail Kite Nesting Success

The total number of Snail Kite nesting initiations by calendar month that have been documented during past Snail Kite studies within WCA 3A from 1979 to 1983 (Snyder *et al.* 1989) are presented in Figure 44. These counts were used to define the peak nesting initiation period within WCA 3A. A comparison of the number of cells within WCA 3A that met the evaluation criteria of favorable surface water conditions for successful Snail Kite nesting per index scenario for the Base and the Basic Rain-Driven alternatives are listed in Table 16. A selection of surface water distribution maps for years with low, moderate, and high areas of favorable surface water conditions for successful Snail Kite nesting within WCA 3A, for both the Base and Basic Rain-Driven alternatives, are presented in Figures 45-50.

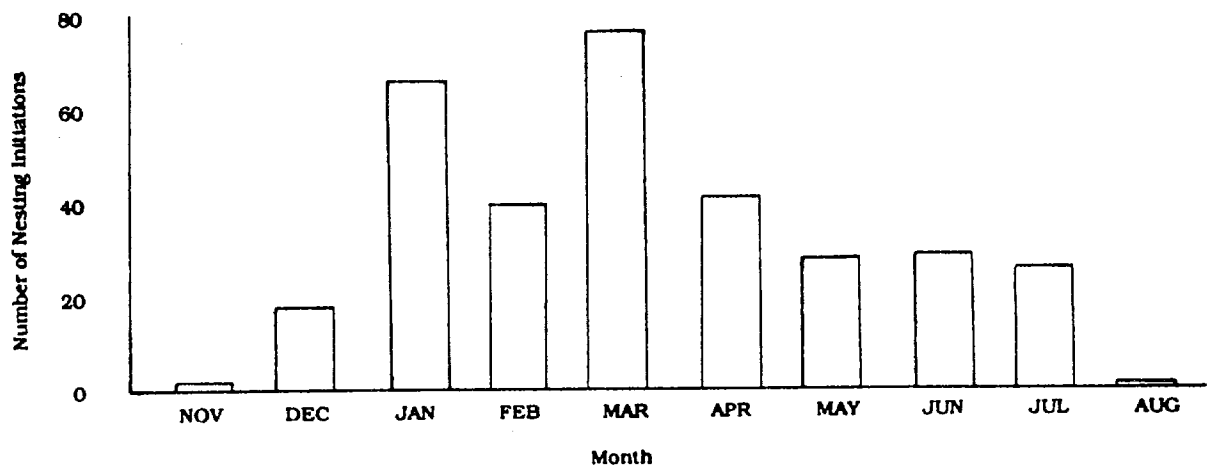

Figure 44. Total number of Snail Kite nesting initiations documented per calendar month in Water Conservation Area 3A from 1979 to 1983. Source: Snyder, Beissinger, and Chandler (1989).

The Basic Rain-Driven alternative consistently provided a greater area of favorable surface water conditions for Snail Kite nesting success within WCA 3A, compared to the Base alternative, over the evaluation period for each of the four index scenarios. Successful nesting, as specified by each selected index scenario, averaged 10 to 20 cells (40 to 80 square miles) greater over the evaluation period for the Basic Rain-Driven alternative compared to the Base alternative. For the earlier, dry season (February) scenarios, this difference represented approximately twice as much area of favorable surface water conditions for successful nesting within WCA 3A, on the average, under the Basic Rain-Driven alternative.

Table 19A. Comparison of the number of 2 by 2 mile cells in State Water Conservation Area 3A of favorable surface water conditions for successful Snail Kite nesting by index scenarios for Base versus Rain-Driven alternatives.

Eval. Year	Base F30	Rain F30	Base F40	Rain F40	Base M20	Rain M20	Base M30	Rain M30
1969	83	92	74	80	96	102	87	88
1970	100	102	91	96	121	121	117	118
1971	2	9	0	6	1	3	0	0
1972	33	79	19	65	33	78	19	65
1973	2	30	1	20	0	0	0	0
1974	6	23	0	20	1	0	0	0
1975	8	10	0	4	9	8	1	1
1976	11	36	2	27	5	28	0	16
1977	25	40	16	39	12	35	3	17
1978	33	79	19	65	40	81	29	69
1979	77	87	63	75	69	80	52	69
1980	83	92	74	81	92	94	82	80
1981	2	30	0	26	1	2	0	0
1982	1	28	0	14	1	24	0	12
Average	33.3	52.6	25.6	44.1	34.4	46.9	27.9	38.2
Std.Dev.	35.1	32.5	32.7	30.4	41.0	42.1	38.8	39.7
Max.	100.0	102.0	91.0	96.0	121.0	121.0	117.0	118.0
Min.	1.0	9.0	0.0	4.0	0.0	0.0	0.0	0.0
Range	99.0	93.0	91.0	92.0	121.0	121.0	117.0	118.0

During drought years of the evaluation period, the Basic Rain-Driven alternative averaged approximately 10 times more area of favorable surface water conditions for nesting within WCA 3A than the Base alternative. This area increased to approximately 14 times that of the Base alternative during drought years for the two earlier, dry season (February) water depth maps, and averaged approximately four times that of the Base alternative for the later, dry season (March) water depth maps. Increased Snail Kite nesting success during drought years would also be expected within WCA 3A under the Basic Rain-Driven alternative compared to the Base alternative.

Bennetts *et al.* (1988) reported a decreasing trend in Snail Kite nesting success throughout the nesting season. From an analysis of factors influencing nesting success, they found that nesting initiation date was the best determinate for predicting Snail Kite nesting success. Increased predation at nest sites as drying of the marsh floor progressed throughout the nesting season, and a progressive depletion of Apple Snail populations, were hypothesized to explain the seasonal decline in nesting success. The increased occurrence of tropical thunderstorms, and associated winds, during the late dry and early wet season months was another factor hypothesized to explain an increase rate of nest failures late in the nesting season. The greater area of favorable surface water conditions for successful Snail Kite nesting within WCA 3A under the Basin Rain-Driven alternative, particularly during the earlier, dry season (February) periods, would therefore be expected to increase Snail Kite nesting success within the basin compared to the Base alternative.

Table 19B. Comparison of the number of 2 by 2 mile cells in State Water Conservation Area 3A of favorable surface water conditions for successful Snail Kite nesting by revised index scenarios for Base versus Rain-Driven alternatives.

Eval. Year	Base M30 4	Rain M30 4	Base M20 4	Rain M20 4	Base M30 3	Rain M30 3	Base M20 3	Rain M20 3
1969	87	88	96	102	87	88	96	102
1970	117	118	121	121	117	118	121	121
1971	0	0	1	3	0	0	1	3
1972	19	65	33	78	19	65	33	78
1973	0	0	0	0	0	0	0	0
1974	0	0	1	0	0	0	1	0
1975	1	1	9	8	1	1	9	8
1976	0	16	5	27	0	16	5	27
1977	3	15	12	30	3	17	12	33
1978	29	69	40	81	29	69	40	81
1979	52	69	69	80	52	69	69	80
1980	82	80	92	94	82	80	92	94
1981	0	0	1	2	0	0	1	2
1982	0	12	1	24	0	12	1	24
Average	27.9	38.1	34.4	46.4	27.9	38.2	34.4	46.6
Std.Dev.	38.8	39.8	41.0	42.3	38.8	39.7	41.0	42.2
Max.	117.0	118.0	121.0	121.0	117.0	118.0	121.0	121.0
Min.	0	0	0	0	0	0	0	0
Range	117.0	118.0	121.0	121.0	117.0	118.0	121.0	121.0

Summary of the Potential Impacts of the Four Alternatives on Snail Kites

The Basic Rain-Driven did not increase dispersal-related mortality of Snail Kites occupying WCA 3A. The annual drydown characteristics of the Basic Rain-Driven alternative resulted in a greater area of surface water being retained in the basin for a longer period during each dry season of the evaluation period compared to Base conditions. The predicted temporal dispersal patterns of Snail Kites from the impoundment under the Basic Rain-Driven alternative resulted in a greater portion of the modeled sample population of dispersed Snail Kites being retained longer in WCA 3A for each dry season of the evaluation period. This was particularly true during the driest or most drought-prone years of the evaluation period. As a result, predicted dispersal-related annual, average annual, and 14-year average relative mortality estimates for Snail Kites during the evaluation period were lower for the Basic Rain-Driven alternative than for the Base alternative.

The impounding of seasonal, surface-water flows in WCA 3A, and the management of these seasonal flows by the strict Minimum Delivery Schedules under Base alternative, reduced the long-term quantity and quality of Snail Kite core habitat within the impoundment, compared to the Basic Rain-Driven alternative. A greater area of core or primary habitat within the designated critical habitat of Snail Kites was maintained in WCA 3A over the 14-year evaluation period with the Basic Rain-Driven alternative than for the Base alternative. The

Table 19B. Continued

Eval. Year	Base F40 4	Rain F40 4	Base F30 4	Rain F30 4	Base F40 3	Rain F40 3	Base F30 3	Rain F30 3
1969	74	80	83	92	74	80	83	92
1970	91	96	100	102	91	91	100	102
1971	0	1	1	3	0	1	1	3
1972	19	65	33	79	19	65	33	79
1973	0	0	0	0	0	0	0	0
1974	0	0	6	0	0	0	6	0
1975	0	4	7	10	0	4	7	10
1976	2	26	11	35	2	27	11	36
1977	14	36	23	37	14	38	23	39
1978	19	64	31	77	19	64	31	77
1979	63	75	77	86	63	75	77	87
1980	74	81	83	92	74	81	93	92
1981	0	2	2	2	0	2	2	2
1982	0	14	1	28	0	14	1	28
Average	25.4	38.9	32.7	45.9	25.4	38.7	33.4	46.2
Std.Dev.	32.8	35.0	35.4	38.6	32.8	34.4	36.5	38.6
Max.	91.0	96.0	100.0	102.0	91.0	91.0	100.0	102.0
Min.	0	0	0	0	0	0	0	0
Range	91.0	96.0	100.0	102.0	91.0	91.0	100.0	102.0

more natural spatio-temporal patterns of variability in seasonal and annual surface water conditions, represented by the Basic Rain-Driven alternative, maintained a greater area of the basin within the upper and lower limits of average drydown intervals required for Snail Kite prey habitat, suitable nesting habitat, and core habitat over the evaluation period, compared to the Base alternative.

The Basic Rain-Driven alternative consistently provided a substantial increase in area (40 - 80 square miles) of favorable surface water conditions for successful Snail Kite nesting within WCA 3A compared to the Base alternative. The Basic Rain-Driven alternative provided approximately twice as much area of favorable, surface water conditions for nesting within WCA 3AS during the earlier, dry season months than the Base alternative. It also maintained approximately ten times as much area of favorable surface water conditions for nesting, on the average, during drought years compared to the Base alternative. Snail Kite nesting success within WCA 3A, therefore, would be expected to increase under the Basic Rain-Driven alternative compared to the Base alternative.

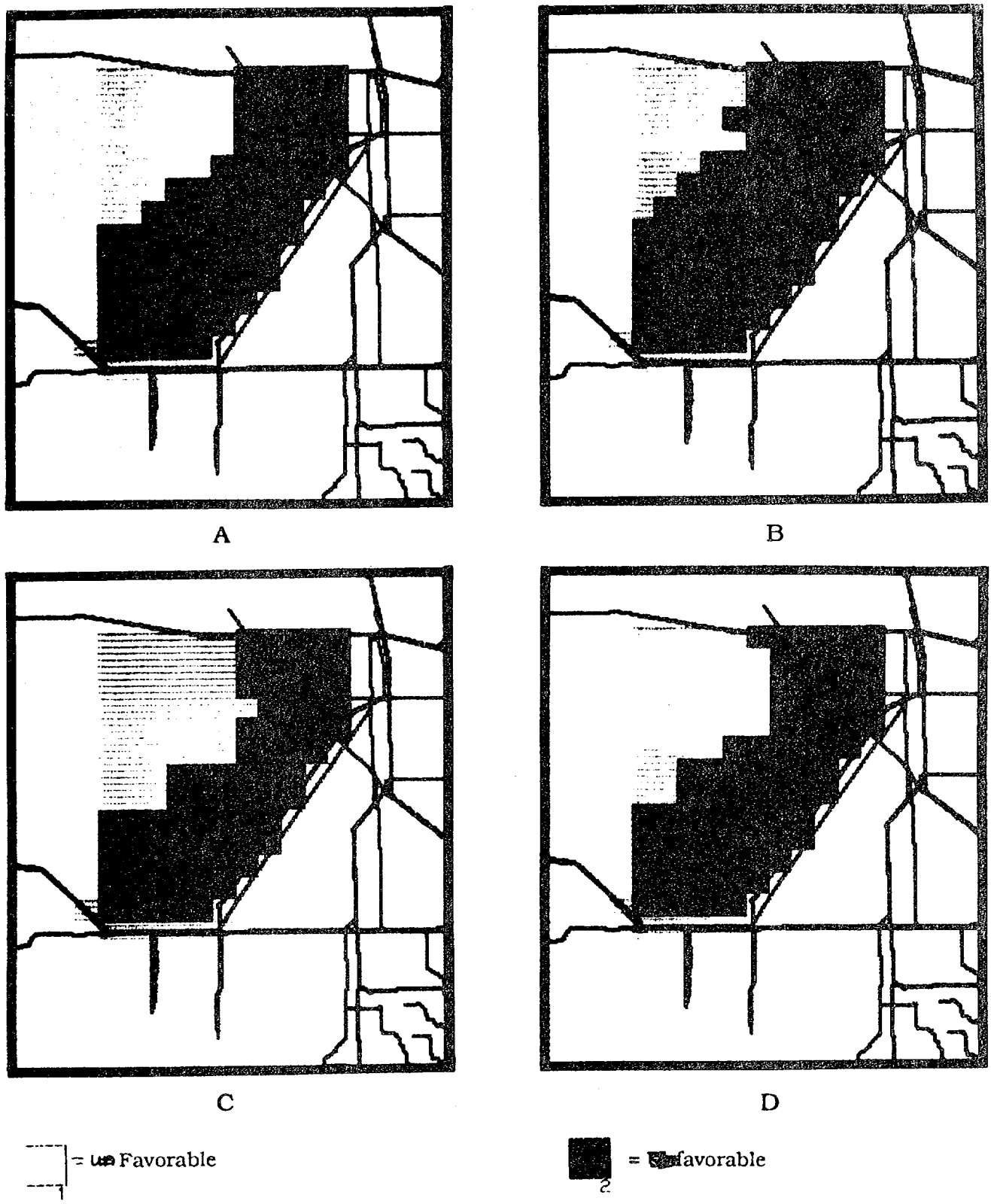

Figure 45. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (a) 69 Feb, 30 cm - Base; (B) 69 Feb, 30 cm - Basic Rain-Driven; (C) 69 Feb, 40 cm - Base; and (D) 69 Feb, 40 cm - Basic Rain-Driven.

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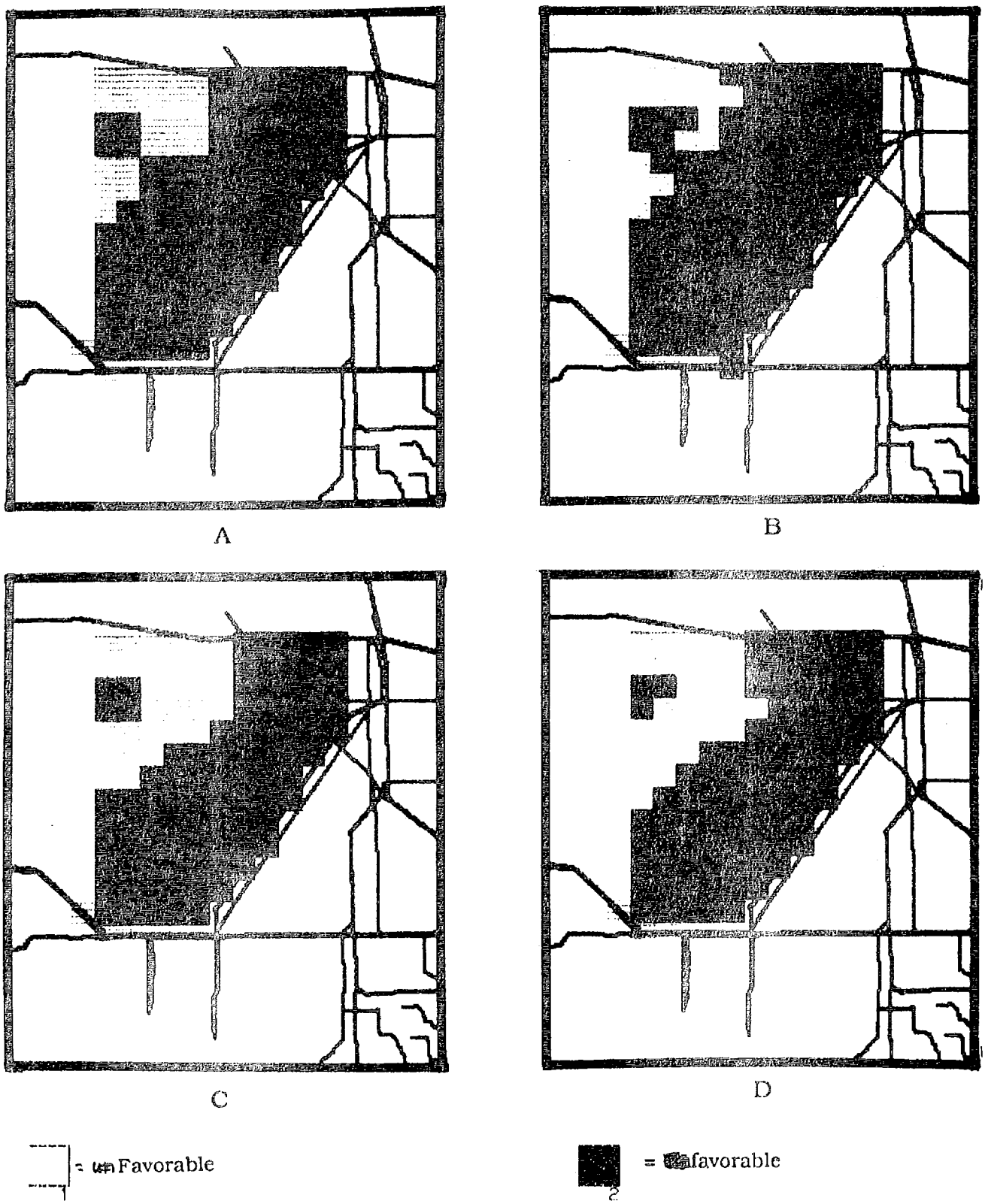

Figure 46. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (A) 69 Mar, 20 cm - Base; (B) 69 Mar, 20 cm - Basic Rain-Driven; (C) 69 Mar, 30 cm - Base; and (D) 69 Mar, 30 cm - Basic Rain-Driven.

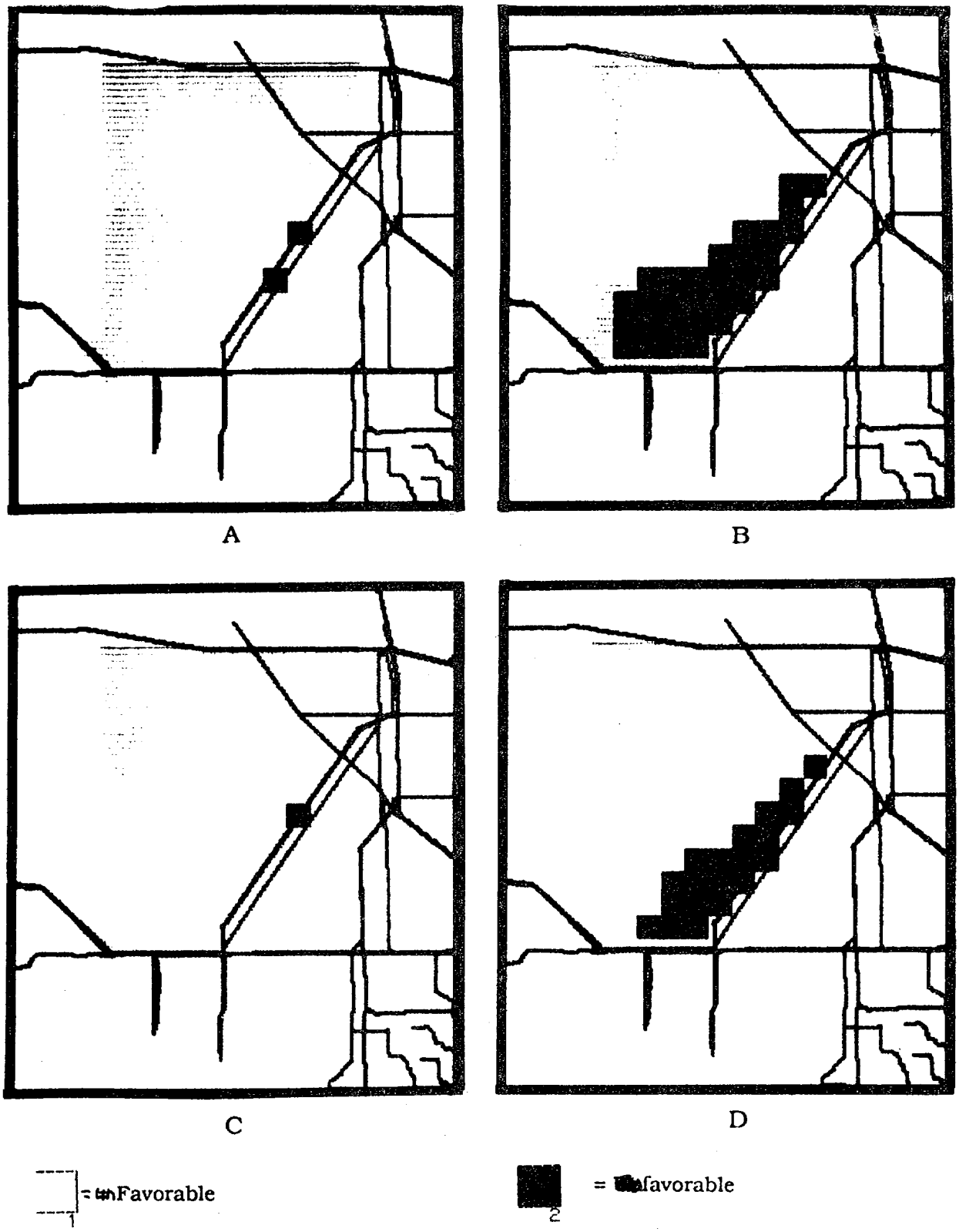

Figure 47. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (A) 73 Feb, 30 cm - Base; (B) 73 Feb, 30 cm - Basic Rain-Driven; (C) 73 Feb, 40 cm - Base; and (D) 73 Feb, 40 cm - Basic Rain-Driven.

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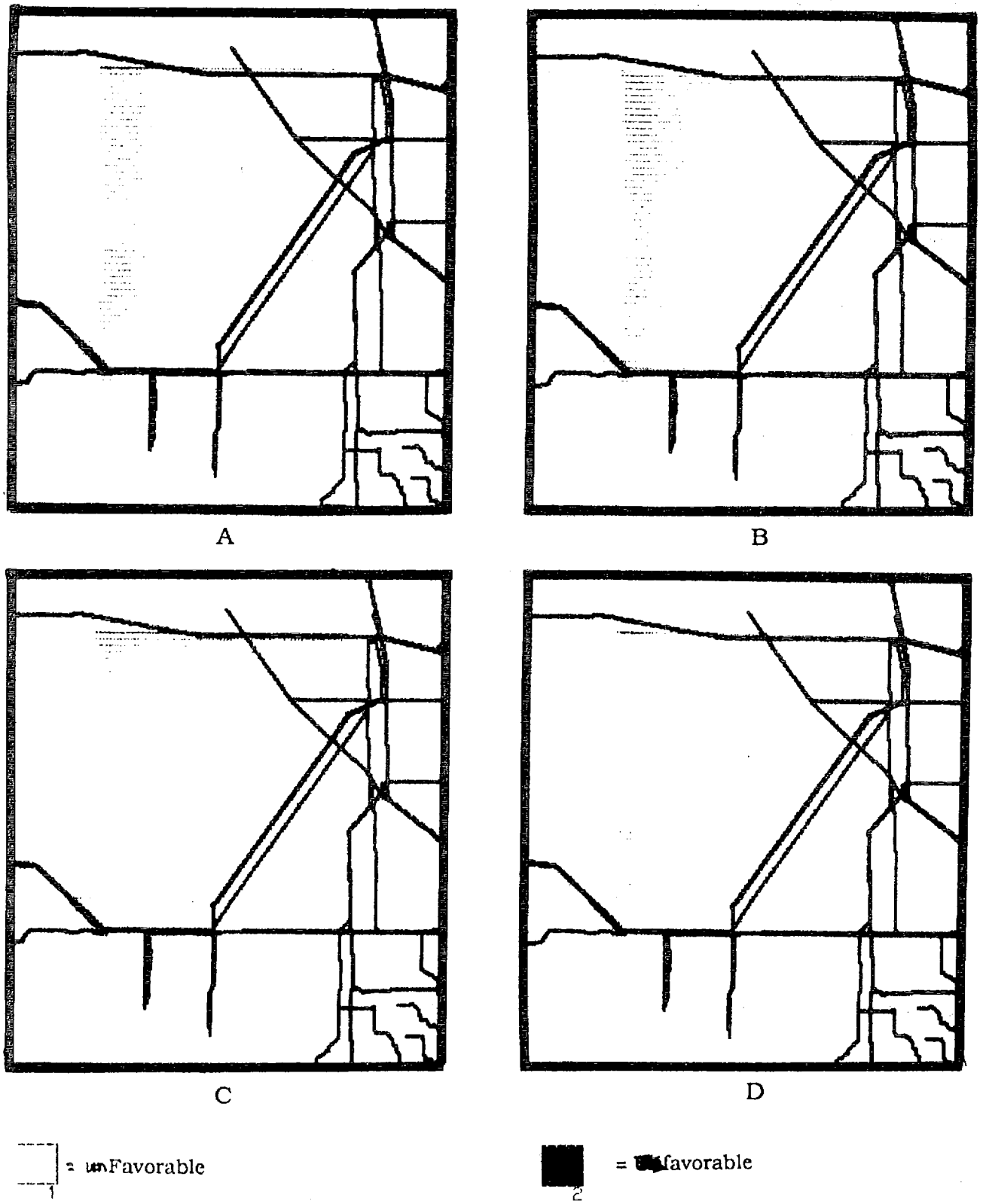

Figure 48. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (A) 73 Mar, 20 cm - Base; (B) 73 Mar, 20 cm - Basic Rain-Driven; (C) 73 Mar, 30 cm - Base; and (D) 73 Mar, 30 cm - Basic Rain-Driven.

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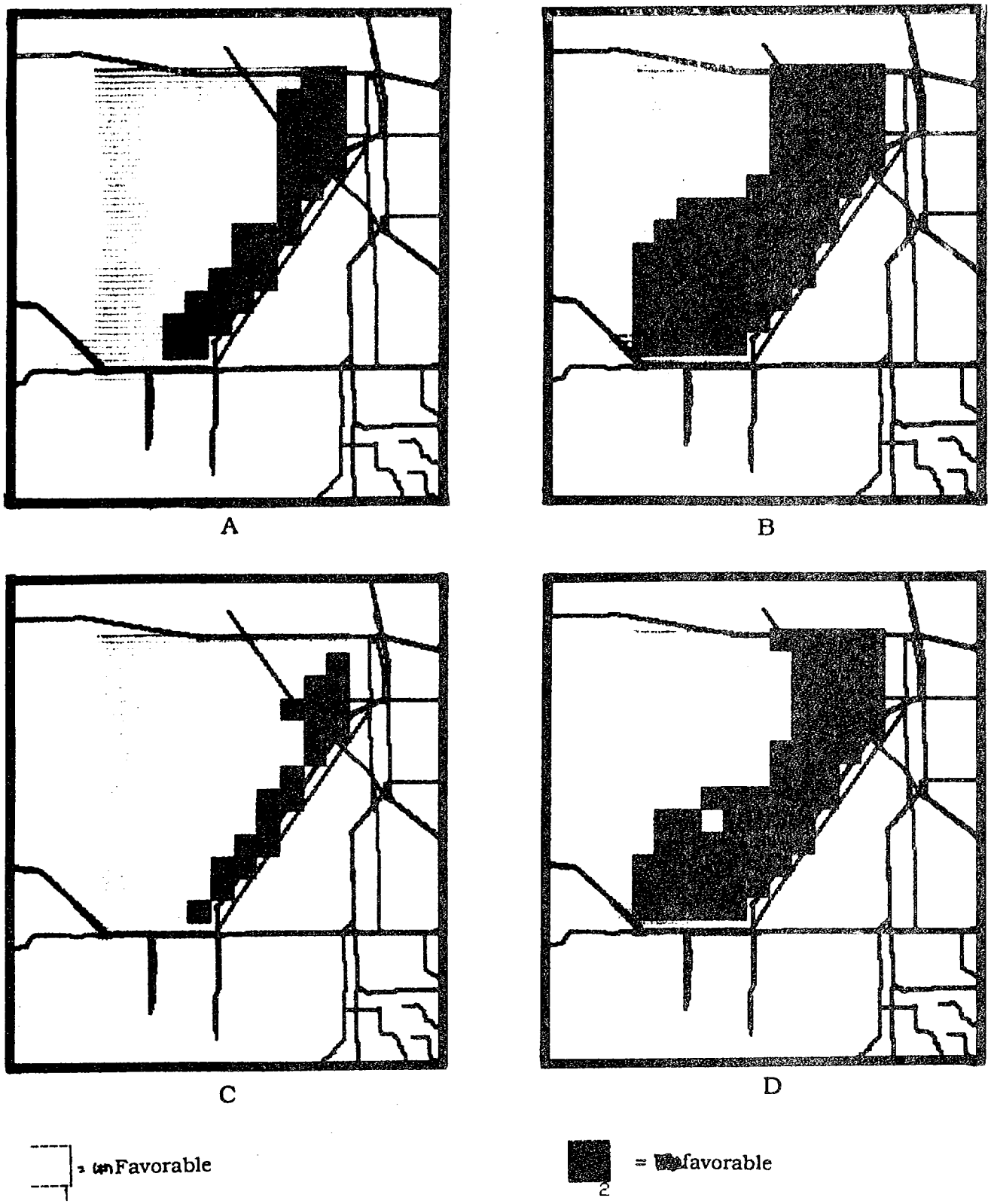

Figure 49. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (A) 78 Feb, 30 cm - Base; (B) 78 Feb, 30 cm - Basic Rain-Driven; (C) 78 Feb, 40 cm - Base; and (D) 78 Feb, 40 cm - Basic Rain-Driven.

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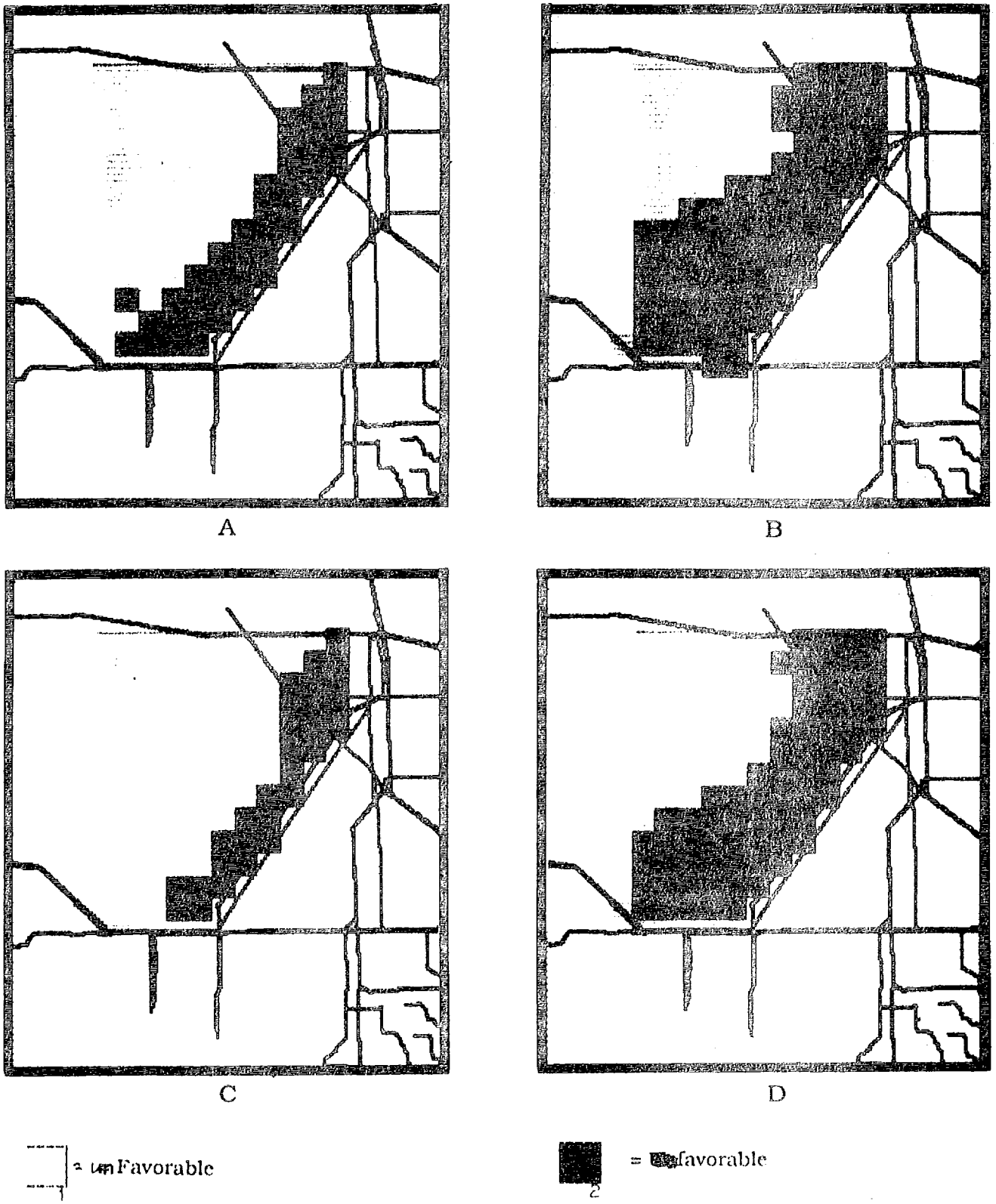

Figure 50. Predicted area of favorable surface water conditions for Snail Kite successful nesting for index scenarios: (A) 78 Mar, 20 cm - Base; (B) 78 Mar, 20 cm - Basic Rain-Driven; (C) 78 Mar, 30 cm - Base; and (D) 78 Mar, 30 cm - Basic Rain-Driven.

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SUMMARY AND DISCUSSION

RESTORATION OF PRE-PROJECT HYDROLOGIC CONDITIONS

The National Park Service's legal mandate for ecosystem management within Everglades National Park can only be achieved through the restoration of a more natural hydrological regime. For this reason, the hydrologic and wildlife impacts of each of the four alternatives were evaluated with respect to the original GDM hydrologic restoration objectives (see page 7), and the results of the natural system hydrological simulation model (MacVicar and Johnson, in prep). This model suggests that under natural conditions, nearly all of the Southern Everglades was inundated during the wet season, due to local rainfall over the Everglades Basin. Similarly, surface water was distributed in accordance with natural topographical gradients, first occupying the deeper central sloughs, and expanding seasonally into the higher, transitional marshes. The slow rate of surface water flow in Everglades marshes produced more gradual flow increases and longer recession periods than occur today under water management. Slower flow rates also caused much of the wet season rainfall that fell over the Northern Everglades to reach the Shark Slough Basin during the early dry season. This natural process maintained surface water flows down the historical eastern flow-way of Shark Slough throughout all but the driest years.

The loss of persistent flows and the resulting reduction of freshwater pools along the coastal mangrove zone, in response to the management of water deliveries to Shark Slough, is thought to be the major factor prompting abandonment of the historical wading bird nesting areas within Everglades National Park. Various alterations in native plant communities and changes in abundance and distribution of Everglades wildlife species have accompanied the construction and operation of the Central and Southern Florida Project. Extensive research on key Everglades wildlife species and their associated habitat requirements suggests that the re-establishment of more natural hydrological conditions will substantially increase the overall biological productivity of the Everglades ecosystem.

POTENTIAL HYDROLOGIC IMPACTS OF THE FOUR ALTERNATIVES

The analyses presented in this report indicate that the Basic Rain-Driven alternative provided the greatest restoration of natural flow timing, seasonal variability, and flow distributions and the greatest restoration of natural surface water hydropatterns and drying characteristics within the study area. The Basic Rain-Driven alternative was also superior to the other alternatives at mitigating large regulatory releases into the Shark Slough Basin. The Modified Rain-Driven alternative produced the greatest increase in water depths, the largest areas of surface water inundation, and the greatest hydroperiod increases throughout the study area. Unfortunately these increases were due to much higher regulatory flows, occurring in response to upstream water management, and were not tied to local rainfall. For this reason, the Modified Rain-Driven alternative did not represent a restoration of more natural hydrological processes. The Base and Modified Base alternatives provided no restoration of natural flow distributions, and produced more destructive regulatory releases because of their strict adherence to the fixed monthly delivery allocations of the Minimum Delivery Schedule, and their inability to divert flows into WCA 3B or Northeast Shark Slough.

Within Northeast Shark Slough, the Basic Rain-Driven alternative provided slightly reduced flows and stage durations compared to the Modified Rain-Driven alternative, but the deliveries were tied more closely to natural upstream rainfall, and required, on average, 65,000 acre-feet lower annual water deliveries to the Shark Slough Basin. The more natural flow distribution characteristics of the Basic Rain-Driven alternative produced a more efficient system of flow

conveyance down the central slough, compared to the Modified Rain-Driven alternative. The Modified Base alternative provided even less improvement in overall water depths, areas of inundation, and hydroperiods within Northeast Shark Slough.

All of the proposed alternatives produced only minor hydrologic improvements in Water Conservation Area 3B and western and central Shark Slough. Under the two rain-driven alternatives, the majority of the water diverted into WCA 3B from WCA 3A was delivered into Northeast Shark Slough. Under the Modified Base, Basic Rain-Driven, and Modified Rain-Driven alternatives, modest increases in water depths, surface water inundations, and hydroperiods occurred in WCA 3B. Within western and central Shark Slough, all three of the above alternatives produced an overall lowering of water levels, and reductions in surface water inundations, and hydroperiods corresponding more closely to the natural system conditions. These reductions occurred in response to the removal of the L-67 extension canal and levee and, for the two rain-driven alternatives, diversion of flows directly into the Northeast Shark Slough flow section.

Within Water Conservation Area 3A, the Modified Base alternative maintained nearly identical water depth conditions as the Base alternative. In contrast, the two rain-driven alternatives lowered average wet season water depths by approximately 0.1 to 0.5 feet, but maintained slightly higher average water depths throughout the dry season until May and June. This reduction of water levels in WCA 3A agreed more closely with the natural system model. Even with the reduced water levels, the two rain-driven alternatives produced substantial increases in the average area of surface water inundations and increased the area of long hydroperiods (11 to 12 months) within WCA 3A. During eight of the 14-years, the Basic Rain-Driven alternative maintained slightly lower water levels in WCA 3A at the end of April, compared to the Base alternative. This led to the entire basin drying out at the end of the dry season during two years. This same trend of basin-wide drying was observed in WCA 3A under actual conditions, and under the natural system model, in response to below normal rainfall. During these low water periods, deliveries to Shark Slough were suspended under the two rain-driven alternatives, so any increased frequency of drydowns appeared to be more in response to the assumed increases in urban water demands than to the water delivery changes in Shark Slough.

The higher flows through the S-12 structures that occurred under the Base and Modified Base alternatives discharged larger volumes of surface water westward into the drainages of Big Cypress and onto the more permeable, sandy marl soils of western Shark Slough. This reduced surface water flows in the main Shark Slough channel. The distribution of flows under the two rain-driven alternatives was farther east, through the historical eastern flow-way as characteristic of natural system modeled flows. This resulted in greater water depths and more persistent dry season flows into the downstream estuaries.

The two rain-driven alternatives did not fully reproduce the natural lag in dry season flows to the central and southern reaches of the Shark Slough Basin as predicted in the natural system model. They produced complete drydowns in the central slough during five of the 14-years, as compared to only one year under the natural simulation model. This deficiency can be corrected through an improved rainfall-runoff relationship. Any improved rainfall formula should more closely approximate the timing and volumes of dry season flows, as observed under the natural system model. Of the four proposed alternatives, the Basic Rain-Driven alternative most closely approximated the timing, seasonal flow volumes, and flow distributions observed under the natural system model.

POTENTIAL WILDLIFE RESPONSES TO THE FOUR ALTERNATIVES

None of the proposed alternatives support populations of marsh fish, alligators, or nesting wading birds as large as those projected under the natural system simulation model. This again appears to be due to the loss of persistent dry season flows into the historical eastern flow-way. Major and frequent drydowns in WCA 3B and Northeast Shark Slough, as modeled under the Base and Modified Base alternatives, would adversely impact marsh fish populations, and affect freshwater flows into the downstream estuaries where nesting wading birds feed. Alligator populations would also be adversely affected by these extreme drydowns. Inter-annual effects of major drydowns require several years for recovery of aquatic food webs (Loftus and Eklund, in prep.). Major drydown intervals, occurring as frequently as that predicted under the Base and Modified Base alternatives, would prevent such recovery and lead to a downward trend in the system's overall aquatic productivity and its capacity to support higher consumer wildlife populations.

The Base and Modified Base alternatives also held too much surface water within the artificially impounded area in the lower end of Water Conservation Area 3A, making the area less suitable as foraging habitat for wading birds and as nesting habitat for alligators. The two rain-driven alternatives were more successful at re-establishing longer hydroperiods in central Shark Slough, as well as providing partial restoration of sheet flow to the adjacent higher marshes. These improvements would help to increase aquatic productivity, increase American Alligator nesting success, and re-establish traditional foraging areas for the Snail Kite, Wood Stork, and other wading birds. This re-establishment of more natural surface water inundations and drying patterns would also help to synchronize foraging habitat conditions with the timing of traditional, and historically more successful, wading bird nesting cycles.

The Basic Rain-Driven alternative produced the greatest improvement in critical habitat for both the endangered Snail Kite and Wood Stork. The annual drydown characteristics in WCA 3A under the Basic Rain-Driven alternative resulted in a greater area of surface water inundation for longer periods into the dry season than under the Base alternative. This resulted in Snail Kites staying longer in WCA 3A during the dry season under the Basic Rain-Driven alternative than the Base alternative. This was particularly true during the driest, or most severe drought years of the 14-year evaluation period. This produced a decrease in the hypothetical dispersal-related mortality estimates for Snail Kites occupying WCA 3A. The long-term impounding and strict adherence to regulation schedules in WCA 3A under the Base, Modified Base, and Modified Rain-Driven alternatives, also resulted in a degradation of the quantity and quality of Snail Kite primary nesting habitat within WCA 3A. The more natural spatial and temporal hydrologic conditions maintained under the Basic Rain-Driven alternative actually increased the area of primary Snail Kite habitat.

The more natural drydown characteristics of the Basic Rain-Driven alternative also provided an increase in the area of shallow water within WCA 3A, making the basin more suitable for Wood Stork foraging. In general, the drydown characteristics in WCA 3B, Northeast Shark Slough, and western Shark Slough under the Base and Modified Base alternatives were too severe to provide adequate foraging conditions for the Wood Stork under any of the proposed alternatives. Additional improvements directed at restoring surface water in the higher marshes of the Rocky Glades and the headwaters of Taylor Slough will be needed to increase the amount of early dry season foraging habitat available for Wood Storks.

Future improvements to the current rainfall formula targeted at increasing flow volumes during the dry season, combined with the improvements in flow distribution as modeled with the Basic Rain-Driven alternative, would best approximate the hydrological conditions observed under the natural system model. Strong, positive responses of the selected key, indicator, and endangered species occurred under the natural system model. These strong responses and the greater abundance and distribution of these wildlife species documented under actual pre-project conditions, support both the need for the structural changes proposed in this GDM, and implementation of the Basic Rain-Driven alternative as the best initial step toward achieving the ecosystem management goals of Everglades National Park.

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APPENDIX A

SURFACE WATER DEPTH

AND

HYDROPERIOD CHARACTERISTICS

FOR THE FOUR STUDY AREAS

Table 1. Seasonal surface water depth characteristics for the Northeast Shark Slough Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	59.43	42.86	44.57	44.00	25.71	22.86	20.00	17.71	13.14	27.43	32.00	29.72	1.71	6.86	3.43	8.57
69 WET	17.14	10.48	13.33	19.52	11.91	10.48	10.00	4.29	10.95	5.24	1.91	1.43	60.00	73.81	74.76	74.76
70 DRY	45.72	27.62	25.72	24.29	18.10	5.72	1.43	2.38	16.19	14.76	8.10	2.38	20.00	51.91	64.76	70.95
70 WET	37.62	28.09	23.81	23.33	15.72	2.38	2.38	2.86	29.05	16.67	8.09	6.19	17.62	52.86	65.72	67.62
71 DRY	81.90	70.00	75.72	75.72	11.43	14.29	15.72	14.29	5.72	14.76	8.10	9.52	0.95	0.95	0.48	0.48
71 WET	42.38	34.76	34.76	33.81	25.24	24.29	29.53	20.47	26.67	26.67	23.33	25.71	5.72	14.29	12.38	20.00
72 DRY	67.62	46.67	41.43	41.43	21.91	31.91	20.48	16.67	8.57	19.05	27.62	28.57	1.91	2.38	10.48	13.34
72 WET	40.95	30.00	27.14	27.14	24.76	9.05	2.86	2.86	21.43	19.05	19.53	15.24	12.86	41.91	50.48	54.76
73 DRY	78.57	62.38	61.91	58.10	13.81	17.62	16.19	17.62	6.19	18.10	20.95	21.90	1.43	1.91	0.95	2.38
73 WET	46.19	36.66	34.29	32.38	22.38	19.53	12.86	11.91	21.91	21.91	21.91	15.72	9.52	21.91	30.95	40.00
74 DRY	84.76	70.00	71.91	70.95	10.48	13.81	15.72	14.28	3.33	14.76	11.43	11.43	1.43	1.43	0.95	3.33
74 WET	42.38	32.86	32.86	32.38	24.76	23.81	15.71	14.28	23.81	25.24	21.90	17.62	9.05	18.09	29.53	35.72
75 DRY	78.57	62.86	66.19	62.86	13.81	20.00	18.57	18.57	6.19	14.76	13.33	14.29	1.43	2.38	1.91	4.29
75 WET	42.38	32.38	30.95	30.47	24.29	22.38	17.62	9.52	23.81	30.47	25.72	25.24	9.53	14.76	25.72	34.76
76 DRY	73.33	52.38	58.57	55.24	19.05	27.14	29.05	27.62	5.71	19.52	12.38	16.19	1.91	0.95	0.00	0.95
76 WET	32.38	24.76	24.76	25.24	15.72	10.00	4.29	2.38	25.71	22.86	18.57	10.95	26.19	42.38	52.38	61.43
77 DRY	69.05	59.05	55.71	54.29	21.43	22.86	20.95	18.57	8.10	14.76	20.00	20.95	1.43	3.33	3.33	6.19
77 WET	55.24	41.43	37.14	34.28	26.19	27.14	24.29	18.10	14.76	23.81	30.00	29.52	3.81	7.62	8.57	18.10
78 DRY	72.86	43.81	37.62	39.52	18.57	31.90	27.14	19.52	7.62	22.86	32.86	35.24	0.95	1.43	2.38	5.72
78 WET	36.67	28.57	26.67	26.19	20.00	16.67	5.24	4.29	29.52	22.38	20.48	15.24	13.81	32.38	47.62	54.29
79 DRY	61.90	46.19	44.76	41.43	28.57	31.90	23.33	23.33	8.10	18.57	28.57	25.24	1.43	3.33	3.33	10.00
79 WET	40.48	33.33	29.05	30.00	30.95	24.76	12.86	8.57	19.05	19.05	29.05	24.29	9.53	22.86	29.05	37.14
80 DRY	50.00	34.29	30.47	30.47	30.00	18.10	11.43	7.14	14.76	35.24	27.62	24.29	5.24	12.38	30.48	38.10
80 WET	44.76	31.43	31.91	30.48	30.95	21.43	16.67	11.43	17.14	36.19	34.29	27.14	7.14	10.95	17.14	30.95
81 DRY	83.33	62.86	68.10	66.19	10.48	18.10	23.81	22.86	5.24	17.62	8.10	10.48	0.95	1.43	0.00	0.48
81 WET	51.43	46.67	47.62	46.19	14.29	7.62	6.67	6.19	14.76	14.76	13.34	9.05	19.52	30.95	32.38	38.57
82 DRY	66.19	44.76	44.29	39.53	22.86	32.86	28.57	25.24	9.05	20.48	21.91	28.57	1.91	1.90	5.24	6.67
82 WET	35.72	27.62	26.19	25.72	14.76	6.19	2.38	2.86	27.62	20.00	13.81	11.43	21.91	46.19	57.62	60.00
WET MN.	40.41	31.36	30.03	29.80	21.57	16.12	11.67	8.57	21.87	21.74	20.14	16.77	16.16	30.78	38.16	44.86
WET S. D.	9.01	8.30	7.81	6.35	6.22	8.23	8.47	5.97	5.81	7.29	2.33	8.57	14.17	18.81	20.19	17.41
WET MD.	41.67	31.91	30.00	30.24	23.34	18.10	11.43	7.38	22.86	22.15	21.19	15.48	11.20	26.91	31.67	39.29
DRY MN.	69.52	51.84	51.93	50.29	19.02	22.08	19.46	17.56	8.42	19.48	19.50	19.91	3.05	6.61	9.12	12.25
DRY S.D.	12.05	13.05	15.73	15.40	6.47	8.25	7.34	6.73	3.77	5.83	9.20	9.43	4.99	13.39	17.85	19.39
DRY MD.	70.96	49.53	50.24	49.15	18.81	21.43	20.24	18.14	8.00	18.34	20.48	21.43	1.43	2.15	2.86	5.96

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Table 2. Surface water hydroperiod characteristics for the Northeast Shark Slough Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	11.43	2.86	5.71	14.29
	1-3	8.57	11.43	11.43	5.71
	4-6	11.42	8.58	5.71	2.86
	7-9	14.28	5.72	2.86	0.00
	10-12	54.29	71.43	74.29	77.15
70-71	0	34.29	22.86	17.14	20.00
	1-3	2.86	5.71	8.57	2.86
	4-6	11.43	2.86	2.86	5.71
	7-9	31.43	22.85	40.00	40.00
	10-12	20.00	45.71	31.43	31.43
71-72	0	37.14	28.57	28.57	28.57
	1-3	5.71	2.86	2.86	2.86
	4-6	8.57	5.71	2.86	5.71
	7-9	34.29	19.99	20.00	17.14
	10-12	14.29	42.86	45.71	45.72
72-73	0	37.14	37.14	25.71	25.71
	1-3	2.86	2.86	2.86	2.86
	4-6	5.72	5.72	0.00	0.00
	7-9	28.57	28.57	17.14	17.14
	10-12	25.72	25.72	54.29	54.29
73-74	0	31.43	22.86	25.71	22.86
	1-3	11.43	5.72	2.86	5.71
	4-6	28.57	14.28	5.72	11.42
	7-9	17.14	48.58	62.86	57.14
	10-12	11.43	8.57	2.86	2.86
74-75	0	34.29	28.57	28.57	28.57
	1-3	5.72	2.86	2.86	0.00
	4-6	14.28	5.71	2.86	8.57
	7-9	34.29	34.28	45.72	37.14
	10-12	11.43	28.57	20.00	25.71
75-76	0	37.14	28.57	28.57	28.57
	1-3	2.86	2.86	2.86	0.00
	4-6	25.72	5.71	8.57	14.29
	7-9	20.00	25.71	42.86	28.57
	10-12	14.28	37.15	17.15	28.56
76-77	0	20.00	17.14	17.14	20.00
	1-3	14.28	11.43	11.43	8.57
	4-6	11.43	2.86	2.86	2.86
	7-9	14.28	20.00	20.00	20.00
	10-12	40.00	48.57	48.57	48.57
77-78	0	40.00	28.57	31.43	28.57
	1-3	17.14	5.72	2.86	5.72
	4-6	11.43	11.43	2.86	5.72
	7-9	2.86	8.57	8.57	2.86
	10-12	28.57	45.71	54.29	57.15
78-79	0	28.57	22.86	22.86	22.86
	1-3	8.57	8.57	5.71	5.72
	4-6	11.43	0.00	0.00	2.86
	7-9	22.86	14.29	11.43	8.57
	10-12	28.57	54.29	60.01	60.00
79-80	0	22.86	17.14	20.00	25.71
	1-3	17.15	14.29	8.57	2.86
	4-6	5.72	0.00	2.86	2.86
	7-9	8.57	11.43	2.86	2.86
	10-12	45.71	57.15	65.72	65.71
80-81	0	37.14	22.86	22.86	25.71
	1-3	5.72	8.57	8.57	2.86
	4-6	17.15	2.86	2.86	8.57
	7-9	17.15	8.58	20.00	14.29
	10-12	22.86	57.14	45.71	48.57
81-82	0	22.86	14.29	20.00	20.00
	1-3	22.86	17.14	8.57	8.57
	4-6	28.58	17.14	20.00	14.28
	7-9	5.72	34.28	37.13	34.28
	10-12	20.00	17.14	14.29	22.86

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	30.33	22.64	22.64	23.96
MEDIAN	0	34.29	22.86	22.86	25.71
ST. D.	0	8.61	8.53	6.85	4.45
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	9.67	7.69	6.16	4.18
MEDIAN	1-3	8.57	5.72	5.71	2.86
ST. D.	1-3	6.45	4.72	3.47	2.76
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	14.73	6.37	4.62	4.09
MEDIAN	4-6	11.43	5.71	2.86	0.00
ST. D.	4-6	7.99	5.24	5.16	5.47
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	19.34	21.76	25.50	21.54
MEDIAN	7-9	17.15	20.00	20.00	17.14
ST. D.	7-9	10.51	12.48	18.53	17.05
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	25.93	41.54	41.10	43.74
MEDIAN	10-12	22.86	45.71	45.71	48.57
ST. D.	10-12	13.48	17.68	21.99	20.45

Table 3. Seasonal surface water depth characteristics for the western/central Shark Slough Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	36.86	27.71	40.86	38.29	34.86	36.57	36.29	38.86	24.00	26.57	20.86	20.57	4.29	9.14	2.00	2.29
69 WET	0.00	0.00	0.24	0.00	5.48	6.67	6.91	5.24	6.90	6.43	6.67	6.43	87.62	86.91	86.19	88.33
70 DRY	6.67	7.62	7.86	3.81	10.00	13.81	11.67	8.57	22.38	24.29	19.76	13.10	60.95	54.28	60.71	74.53
70 WET	6.90	8.09	5.24	3.34	10.95	11.91	10.71	11.67	21.43	22.62	20.00	16.67	60.71	57.38	64.05	68.34
71 DRY	54.05	57.86	63.10	62.86	21.91	22.38	20.48	20.72	16.43	12.38	9.29	9.29	7.62	7.38	7.14	7.14
71 WET	26.19	30.72	32.38	31.67	30.71	29.53	33.57	30.95	25.72	24.53	24.29	24.05	17.38	15.24	9.76	13.33
72 DRY	25.71	30.00	31.91	29.52	37.62	36.67	38.57	36.19	23.33	22.86	20.72	23.81	13.33	10.48	8.81	10.48
72 WET	10.72	12.38	9.76	9.05	17.38	16.90	14.29	14.29	29.76	32.38	28.81	26.91	42.14	38.33	47.15	49.76
73 DRY	41.66	45.00	49.52	46.91	25.95	25.48	28.33	29.29	20.95	18.57	13.34	14.52	11.43	10.95	8.81	9.29
73 WET	15.72	18.33	18.57	17.86	28.81	28.81	26.90	24.76	27.86	28.10	27.38	24.52	27.62	24.76	27.14	32.86
74 DRY	54.76	57.86	61.19	59.53	20.00	20.95	21.91	22.14	16.67	13.10	9.76	10.72	8.57	8.10	7.14	7.62
74 WET	18.10	21.19	21.19	19.76	29.29	30.00	29.53	27.62	26.43	29.53	27.86	27.38	26.19	19.29	21.43	25.24
75 DRY	43.34	47.14	54.52	52.62	27.62	28.33	26.67	26.91	19.29	15.95	11.43	12.62	9.76	8.57	7.38	7.85
75 WET	14.53	17.62	16.67	15.72	28.81	28.57	27.38	24.52	28.57	30.00	31.90	31.19	28.09	23.81	24.04	28.57
76 DRY	32.62	40.95	49.52	48.33	33.81	33.57	32.38	31.91	25.24	18.33	12.14	13.10	8.33	7.14	5.95	6.67
76 WET	6.91	8.34	7.62	6.67	16.67	17.86	16.19	14.29	29.52	29.76	26.67	24.29	46.91	44.04	49.53	54.76
77 DRY	43.81	45.72	48.81	47.14	25.95	26.43	25.95	25.24	18.81	17.62	15.95	17.14	11.43	10.24	9.28	10.48
77 WET	24.52	29.52	29.53	26.43	32.14	34.52	37.62	35.00	30.00	23.81	24.52	28.33	13.33	12.14	8.33	10.24
78 DRY	22.86	26.67	26.19	24.05	34.52	36.67	44.76	39.52	27.86	22.14	22.86	24.76	14.76	14.52	6.19	11.67
78 WET	8.81	11.20	9.29	8.33	21.91	22.62	17.86	15.48	31.19	31.43	30.00	27.14	38.10	34.76	42.86	49.05
79 DRY	29.05	32.62	35.00	33.57	34.29	34.28	33.10	32.86	23.81	21.43	21.19	22.62	12.85	11.67	10.71	10.95
79 WET	17.62	20.48	17.39	15.48	29.05	28.81	24.05	22.62	24.52	26.19	34.05	31.91	28.81	24.52	24.52	30.00
80 DRY	17.38	16.43	16.67	15.24	30.71	25.47	23.57	20.95	34.53	37.14	37.38	35.00	17.38	20.95	22.38	28.81
80 WET	15.96	18.10	17.62	15.24	24.05	25.95	27.86	22.86	34.05	33.33	30.71	34.05	25.95	22.62	23.80	27.86
81 DRY	43.81	47.86	61.19	58.33	24.29	25.24	27.14	25.00	20.72	17.14	7.38	11.19	11.19	9.76	4.29	5.48
81 WET	31.43	33.57	35.24	33.57	15.24	16.19	14.29	13.10	19.53	20.24	21.19	20.00	33.81	30.00	29.29	33.34
82 DRY	22.62	27.62	33.81	29.29	38.81	41.43	38.57	39.76	26.43	20.72	17.14	18.81	12.14	10.24	10.48	12.14
82 WET	7.38	9.05	8.10	8.09	14.29	15.71	14.29	11.67	27.14	29.29	26.19	23.81	51.19	45.95	51.43	56.43
WET MN.	14.63	17.04	16.35	15.09	21.77	22.43	21.53	19.58	25.90	26.26	25.73	24.76	37.70	34.27	36.39	40.58
WET S.D.	8.65	9.66	10.52	10.16	8.45	8.23	9.23	8.54	6.65	6.88	6.73	6.99	19.36	19.77	21.68	21.64
WET MD.	15.13	17.86	17.03	15.36	22.98	24.29	20.96	19.05	27.50	28.70	27.03	25.72	31.31	27.38	28.22	33.10
DRY MN.	33.94	36.50	41.44	39.25	28.60	29.09	29.24	28.42	22.89	20.59	17.09	17.66	14.57	13.82	12.23	14.67
DRY S.D.	14.01	14.88	17.03	17.55	7.95	7.66	8.70	8.89	4.80	6.24	7.73	7.13	13.74	12.16	14.70	18.25
DRY MD.	34.74	36.79	44.84	42.60	29.17	27.38	27.74	28.10	22.86	19.65	16.55	15.83	11.43	10.24	8.10	9.89

Table 4. Surface water hydroperiod characteristics for western/central Shark Slough Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	1.43	2.86	0.00
	7-9	8.57	8.57	5.72	5.72
	10-12	91.42	90.00	91.43	94.29
70-71	0	2.86	7.14	2.86	0.00
	1-3	4.29	0.00	2.86	2.86
	4-6	4.29	5.72	5.72	5.72
	7-9	20.00	24.29	44.29	47.14
	10-12	68.58	62.86	44.29	44.29
71-72	0	10.00	11.43	11.43	11.43
	1-3	5.72	5.72	8.58	7.15
	4-6	1.43	5.72	5.72	5.72
	7-9	41.42	40.00	38.57	38.57
	10-12	41.43	37.15	35.72	37.15
72-73	0	8.57	10.00	8.57	5.71
	1-3	2.86	2.86	0.00	2.86
	4-6	2.86	2.86	10.01	10.00
	7-9	5.72	8.58	11.43	7.14
	10-12	80.00	75.72	70.01	74.28
73-74	0	5.71	7.14	7.14	7.14
	1-3	4.29	5.72	4.29	4.29
	4-6	8.58	10.01	12.86	11.43
	7-9	52.86	55.72	61.43	58.57
	10-12	28.58	21.43	14.29	18.58
74-75	0	7.14	8.57	8.57	8.57
	1-3	4.29	5.72	4.29	4.29
	4-6	7.15	8.58	12.86	12.86
	7-9	55.71	52.86	62.86	58.57
	10-12	25.72	24.29	11.43	15.72
75-76	0	7.14	8.57	7.14	7.14
	1-3	7.15	7.15	5.72	7.15
	4-6	4.29	7.15	14.28	12.85
	7-9	22.86	31.43	42.85	41.43
	10-12	58.57	45.71	30.00	31.42
76-77	0	0.00	2.86	1.43	1.43
	1-3	7.14	5.72	7.15	7.14
	4-6	4.29	4.29	4.29	4.29
	7-9	14.29	20.00	30.00	27.14
	10-12	74.28	67.14	57.14	60.00
77-78	0	10.00	11.43	12.86	11.43
	1-3	4.29	7.15	8.57	10.01
	4-6	5.72	5.72	2.86	1.43
	7-9	20.00	20.00	21.43	14.29
	10-12	60.00	55.72	54.29	62.86
78-79	0	5.71	5.71	5.71	5.71
	1-3	2.86	5.72	2.86	1.43
	4-6	5.72	4.29	5.72	5.72
	7-9	17.15	21.42	18.56	17.14
	10-12	68.57	62.86	67.15	70.00
79-80	0	5.71	5.71	5.71	5.71
	1-3	5.72	7.14	7.14	4.29
	4-6	5.72	4.29	1.43	4.29
	7-9	7.14	10.00	10.01	8.58
	10-12	75.72	72.86	75.72	77.14
80-81	0	11.43	11.43	8.57	8.57
	1-3	4.29	5.72	7.15	5.72
	4-6	1.43	2.86	7.15	7.15
	7-9	7.14	4.29	21.44	17.14
	10-12	75.71	75.72	55.72	61.43
81-82	0	4.29	4.29	5.71	4.29
	1-3	7.14	8.58	7.15	4.29
	4-6	11.43	17.13	25.71	24.28
	7-9	45.71	42.87	42.86	45.71
	10-12	31.43	27.15	18.58	21.43

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	6.04	7.25	6.59	5.93
MEDIAN	0	5.71	7.14	7.14	5.71
ST. D.	0	3.60	3.52	3.67	3.77

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	4.62	5.17	5.06	4.73
MEDIAN	1-3	4.29	5.72	5.72	4.29
ST. D.	1-3	2.03	2.65	2.95	2.70

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	4.84	6.16	8.58	8.13
MEDIAN	4-6	4.29	5.72	5.72	5.72
ST. D.	4-6	3.12	4.05	6.62	6.32

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	24.51	26.16	31.65	29.78
MEDIAN	7-9	20.00	21.42	30.00	27.14
ST. D.	7-9	18.09	17.19	18.82	19.44

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	60.00	55.28	48.14	51.43
MEDIAN	10-12	68.57	62.86	54.29	60.00
ST. D.	10-12	21.52	22.22	25.03	25.13

Table 5. Seasonal surface water depth characteristics for the Water Conservation Area 3A Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	3.74	3.09	3.42	3.26	16.10	13.17	14.15	13.50	13.82	12.19	14.31	13.01	66.34	71.55	68.13	70.25
69 WET	0.00	0.00	0.00	0.00	0.27	0.27	0.27	0.14	4.47	4.47	3.66	3.39	95.26	95.26	96.08	96.48
70 DRY	0.00	0.00	0.00	0.00	2.44	3.52	0.81	0.27	14.23	14.09	9.49	4.88	83.33	82.38	89.70	94.86
70 WET	0.00	0.00	0.00	0.00	2.17	2.03	2.57	2.17	9.76	9.76	7.59	8.13	88.08	88.21	89.84	89.70
71 DRY	47.56	43.77	44.17	37.94	27.51	26.56	21.14	23.99	12.74	13.28	10.98	12.60	12.20	16.40	23.71	25.48
71 WET	2.71	1.36	2.85	1.36	35.91	28.86	35.23	28.05	21.95	22.77	20.19	21.55	39.43	47.02	41.73	49.05
72 DRY	5.56	1.36	0.95	0.95	36.32	23.04	20.19	20.87	26.15	21.14	20.73	21.82	31.98	54.47	58.14	56.37
72 WET	0.00	0.00	0.00	0.00	8.94	8.67	9.35	10.30	19.24	18.70	20.33	19.24	71.82	72.63	70.33	70.46
73 DRY	48.38	41.73	37.40	36.72	27.23	24.93	22.50	22.77	12.20	13.42	12.47	13.96	12.20	19.92	27.64	26.56
73 WET	6.77	4.88	4.34	3.79	19.38	18.43	22.22	20.33	12.20	13.82	13.82	15.31	61.66	62.87	59.62	60.57
74 DRY	45.12	38.48	39.30	37.67	23.71	23.17	21.14	21.82	14.09	12.74	10.98	12.74	17.07	25.61	28.59	27.78
74 WET	0.68	0.81	3.12	0.41	21.41	21.68	22.63	22.49	14.36	15.04	15.17	16.94	63.55	62.47	59.08	60.17
75 DRY	44.31	40.79	41.60	32.66	24.93	24.39	23.98	26.42	16.67	15.72	11.92	16.80	14.09	19.11	22.50	24.12
75 WET	0.14	0.14	2.17	0.14	14.50	14.09	15.72	13.82	21.14	21.55	20.05	23.58	64.23	64.23	62.06	62.47
76 DRY	28.59	21.00	18.83	16.67	37.40	35.91	36.18	32.93	15.31	17.89	14.23	17.75	18.70	25.21	30.76	32.66
76 WET	0.00	0.00	0.27	0.00	6.37	7.18	7.05	6.37	15.04	17.07	21.00	17.89	78.60	75.75	71.68	75.75
77 DRY	33.61	28.19	24.39	22.49	26.56	26.96	26.69	25.07	15.85	14.77	14.91	16.81	23.99	30.08	34.01	35.64
77 WET	4.07	3.25	4.20	2.57	33.34	30.22	29.68	26.29	26.69	28.05	23.17	23.31	35.91	38.48	42.96	47.83
78 DRY	19.24	12.60	9.08	8.26	32.25	26.42	18.70	18.16	29.14	26.29	22.22	21.14	19.38	34.69	50.00	52.44
78 WET	0.00	0.00	0.00	0.00	13.96	10.70	9.35	8.40	15.45	15.31	15.72	13.28	70.60	73.98	74.93	78.32
79 DRY	6.91	3.79	4.47	4.06	20.19	16.40	17.62	17.21	22.22	14.77	17.21	15.45	50.68	65.04	60.71	63.28
79 WET	5.28	4.20	4.34	4.07	15.58	11.39	14.23	10.16	22.63	17.08	18.70	16.40	56.50	67.35	62.74	69.38
80 DRY	2.85	2.30	2.98	1.89	14.50	11.79	12.20	10.03	17.07	13.15	16.67	15.04	65.58	72.77	68.16	73.03
80 WET	2.71	2.30	2.98	2.03	16.26	15.85	16.80	16.26	18.02	15.99	17.75	15.85	63.01	65.86	62.47	65.85
81 DRY	50.81	39.57	37.81	28.45	29.81	27.51	22.76	25.61	11.38	15.17	11.65	14.77	8.00	17.75	27.78	31.17
81 WET	24.93	21.95	24.26	18.29	11.25	11.38	10.16	16.40	10.57	13.01	16.26	12.74	53.26	53.66	49.32	52.57
82 DRY	35.37	26.29	22.22	29.00	38.62	36.99	37.67	37.94	13.82	17.34	16.67	16.13	12.19	19.38	23.44	16.94
82 WET	0.00	0.00	0.00	0.00	2.71	2.85	2.98	3.39	9.62	10.71	14.36	12.06	87.67	86.45	82.66	84.55
WET MN.	3.38	2.78	3.47	2.33	14.43	13.11	14.16	13.18	15.80	15.95	16.27	15.69	66.40	68.16	66.11	68.80
WET ST.D.	6.61	5.78	6.25	4.82	10.71	9.24	10.36	8.88	6.17	5.86	5.33	5.62	17.38	15.70	16.19	14.88
WET MD.	0.41	0.48	2.51	0.28	14.23	11.39	12.20	12.06	15.25	15.65	17.01	16.13	63.89	66.61	62.61	67.62
DRY MN.	26.58	21.64	20.47	18.57	25.54	22.91	9.22	21.19	16.76	15.85	14.60	15.21	31.12	39.60	43.81	45.04
DRY ST.D.	19.54	17.38	16.99	15.14	9.91	9.09	21.12	9.35	5.34	3.84	3.76	4.09	24.77	24.13	21.68	23.37
DRY MD.	31.10	23.65	20.53	19.58	26.90	24.66	21.14	22.30	14.77	14.77	14.27	15.25	19.04	27.85	32.39	34.15

Table 6. Surface water hydroperiod characteristics for Water Conservation Area 3A. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	0.00	0.00	0.00	0.00
	10-12	100.00	100.00	100.00	100.00
70-71	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	33.34	23.58	19.51	21.95
	10-12	66.66	76.42	80.49	78.05
71-72	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.81	0.00	0.00	0.00
	7-9	15.44	4.88	6.50	4.06
	10-12	83.74	95.12	93.50	95.94
72-73	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	26.83	22.77	16.26	18.69
	10-12	73.17	77.24	83.75	81.30
73-74	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	2.44	0.00	0.00	1.63
	7-9	73.17	48.79	48.77	43.90
	10-12	24.39	51.21	51.22	54.47
74-75	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	2.44	1.63	0.81	1.63
	7-9	70.73	64.23	60.17	41.46
	10-12	26.83	34.15	39.03	56.92
75-76	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.81	0.81	0.81	0.00
	7-9	61.79	37.40	35.77	30.09
	10-12	37.40	61.79	63.42	69.91
76-77	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	4.88	4.06	3.25	4.06
	10-12	95.12	95.94	96.75	95.94
77-78	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	26.83	13.01	6.51	4.88
	10-12	73.18	86.99	93.50	95.12
78-79	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	6.50	2.44	2.44	2.44
	10-12	93.50	97.57	97.56	97.56
79-80	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	0.00	0.00	0.00
	7-9	7.32	4.88	6.51	4.06
	10-12	92.68	95.12	93.50	95.94
80-81	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	10.57	9.76	8.13	6.51
	7-9	17.07	8.13	8.95	7.32
	10-12	72.36	82.11	82.93	86.18
81-82	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	18.70	13.01	11.38	14.63
	7-9	62.61	54.47	55.28	49.59
	10-12	18.69	32.52	33.34	35.78

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	0.00	0.00	0.00	0.00
MEDIAN	0	0.00	0.00	0.00	0.00
ST. D.	0	0.00	0.00	0.00	0.00
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	0.00	0.00	0.00	0.00
MEDIAN	1-3	0.00	0.00	0.00	0.00
ST. D.	1-3	0.00	0.00	0.00	0.00
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	2.75	1.94	1.63	1.87
MEDIAN	4-6	0.00	0.00	0.00	0.00
ST. D.	4-6	5.60	4.27	3.68	4.24
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	31.27	22.20	20.76	17.89
MEDIAN	7-9	26.83	13.01	8.95	7.32
ST. D.	7-9	26.74	22.07	21.60	17.83
STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	65.98	75.86	77.62	80.24
MEDIAN	10-12	73.17	82.11	83.75	86.18
ST. D.	10-12	29.23	23.78	23.47	20.38

Table 7. Seasonal surface water depth characteristics for the Water Conservation Area 3B Basin. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	BA%DRY	BC%DRY	MU%DRY	MP%DRY	BA%TRAN	BC%TRAN	MU%TRAN	MP%TRAN	BA%SHAL	BC%SHAL	MU%SHAL	MP%SHAL	BA%DEEP	BC%DEEP	MU%DEEP	MP%DEEP
69 DRY	6.26	6.25	0.00	0.00	11.88	4.38	6.25	6.25	34.38	19.38	10.63	9.38	47.51	70.00	83.13	84.38
69 WET	0.00	0.00	0.00	0.00	5.21	0.00	0.00	0.00	1.56	2.08	0.00	0.00	93.24	97.92	100.00	100.00
70 DRY	5.22	0.52	0.00	0.00	5.21	4.17	0.52	0.00	5.21	3.65	3.13	1.56	84.38	91.68	96.36	98.44
70 WET	5.73	0.52	0.00	0.00	5.73	5.73	1.04	1.04	5.21	2.61	1.56	0.00	83.34	91.15	97.40	98.96
71 DRY	39.07	34.38	35.94	26.57	22.92	20.84	23.96	30.21	22.40	27.61	19.27	25.00	15.63	17.19	20.84	18.23
71 WET	22.40	18.24	13.55	10.42	38.02	27.61	45.84	32.30	30.21	38.03	27.61	39.07	9.38	16.15	13.02	18.23
72 DRY	25.53	12.51	7.29	7.82	43.75	36.46	33.34	32.82	17.19	36.46	42.19	42.19	13.55	14.59	17.19	17.19
72 WET	6.26	3.13	0.52	0.00	10.94	3.13	4.69	5.73	27.61	20.32	25.00	26.57	55.21	73.45	69.80	67.72
73 DRY	43.76	33.86	38.03	35.42	30.73	29.17	30.73	32.82	18.75	26.04	22.40	23.44	6.78	10.94	8.86	8.34
73 WET	14.59	11.98	6.25	6.77	25.53	18.23	25.00	17.71	38.54	41.15	34.90	33.86	21.36	28.65	33.86	41.67
74 DRY	48.96	39.59	43.23	41.15	25.52	29.69	30.73	30.73	17.19	20.84	17.71	19.79	8.34	9.90	8.33	8.34
74 WET	12.51	11.99	6.25	4.17	26.57	21.36	33.86	22.92	41.67	45.84	38.02	42.19	19.28	20.84	21.88	30.73
75 DRY	38.55	32.82	36.47	30.74	35.42	33.34	40.63	40.63	15.11	21.36	15.11	17.19	10.94	12.50	7.82	11.46
75 WET	11.98	10.94	6.77	4.69	26.57	23.96	30.21	22.40	41.15	42.71	41.15	42.71	20.32	22.40	21.88	30.21
76 DRY	27.09	19.80	16.15	14.07	45.31	42.19	41.15	38.55	18.23	26.57	32.30	33.86	9.38	11.46	10.42	13.55
76 WET	5.21	3.13	0.52	0.00	6.77	4.69	7.29	3.65	23.96	22.92	24.48	19.27	64.07	69.28	67.71	77.09
77 DRY	23.96	18.24	23.96	18.75	31.77	31.25	32.29	34.38	20.31	24.48	31.77	31.78	23.96	26.05	11.98	15.11
77 WET	23.96	18.76	17.19	9.90	36.98	33.86	42.19	39.06	24.48	31.77	29.17	35.42	14.59	15.64	11.47	15.63
78 DRY	33.34	18.23	15.63	10.94	36.98	38.55	32.29	36.98	17.19	29.17	38.02	38.03	12.51	14.08	14.07	14.07
78 WET	7.82	4.69	0.52	0.00	13.55	7.82	6.77	4.69	39.06	34.90	28.13	18.23	39.59	52.61	64.59	77.09
79 DRY	13.03	7.30	3.65	1.57	32.82	25.00	11.98	11.46	38.02	48.44	51.56	52.09	16.15	19.28	32.82	34.90
79 WET	11.46	7.82	4.69	0.00	21.88	18.23	21.88	18.75	41.67	41.15	47.40	39.07	25.01	32.82	26.05	42.19
80 DRY	8.34	6.25	0.00	0.00	18.76	4.17	7.82	6.77	50.52	46.36	19.27	9.90	22.40	43.24	72.92	83.34
80 WET	6.78	5.22	2.61	0.00	19.28	10.94	19.79	13.02	45.84	44.27	47.92	37.50	28.13	39.59	29.69	49.48
81 DRY	48.44	38.03	41.16	32.30	33.34	30.21	34.38	36.46	11.98	22.40	16.15	21.36	6.25	9.38	8.33	9.90
81 WET	24.49	21.88	27.61	17.71	15.63	13.02	11.46	14.07	26.04	26.05	28.13	20.31	33.86	39.07	32.82	47.92
82 DRY	20.32	14.07	15.63	14.59	49.48	43.23	46.88	45.84	21.88	31.25	26.57	29.17	8.34	11.47	10.94	10.42
82 WET	6.26	1.57	0.00	0.52	5.21	5.73	4.17	1.56	14.59	14.59	20.32	17.19	73.97	78.13	75.52	80.74
WET MN.	11.39	8.56	6.18	3.87	18.42	13.88	18.16	14.06	28.69	29.17	28.13	26.53	41.53	48.41	47.55	55.55
WET ST.D.	7.59	7.22	8.14	5.52	11.29	10.21	15.42	12.19	13.94	14.87	14.30	14.49	27.45	28.54	30.64	28.12
WET MD.	9.64	6.52	3.65	0.26	17.46	11.98	15.63	13.55	28.91	33.34	28.13	30.22	31.00	39.33	33.34	48.70
DRY MN.	27.28	20.13	19.80	16.71	30.28	26.62	26.64	27.42	22.03	27.43	24.72	25.34	20.44	25.84	28.86	30.55
DRY S.D.	15.30	13.27	16.49	14.36	12.53	13.56	14.39	14.72	11.60	11.25	13.18	13.77	21.27	25.28	31.02	32.37
DRY MD.	26.31	18.24	15.89	14.33	32.30	29.95	31.51	32.82	18.49	26.31	20.84	24.22	13.03	14.34	13.03	14.59

Table 8. Surface water hydroperiod characteristics for Water Conservation Area 3B. (Base = BA, Modified Base = BC, Basic Rain-Driven = MU, and Modified Rain-Driven = MP)

YEAR	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
69-70	0	0.00	0.00	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	3.13	0.00	0.00	0.00
	7-9	3.13	0.00	0.00	0.00
	10-12	93.75	100.01	100.00	100.00
70-71	0	3.13	0.00	0.00	0.00
	1-3	3.13	0.00	0.00	0.00
	4-6	0.00	3.13	0.00	0.00
	7-9	6.25	9.38	6.25	6.25
	10-12	87.51	87.51	93.76	93.76
71-72	0	9.38	3.13	0.00	0.00
	1-3	6.26	9.38	0.00	3.13
	4-6	12.51	3.13	12.50	6.26
	7-9	9.39	12.50	12.51	12.51
	10-12	62.50	71.88	75.01	78.13
72-73	0	6.25	3.13	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	3.13	0.00	0.00
	7-9	9.38	6.26	18.76	18.76
	10-12	84.39	87.51	81.26	81.26
73-74	0	6.25	3.13	0.00	0.00
	1-3	0.00	3.13	0.00	0.00
	4-6	6.26	6.26	9.38	12.51
	7-9	53.13	25.00	34.39	31.25
	10-12	34.38	62.51	56.25	56.26
74-75	0	6.25	0.00	0.00	0.00
	1-3	3.13	12.51	0.00	3.13
	4-6	6.26	0.00	15.63	3.13
	7-9	37.51	21.89	31.26	37.50
	10-12	46.88	65.63	53.13	56.25
75-76	0	9.38	6.25	0.00	0.00
	1-3	3.13	3.13	0.00	0.00
	4-6	3.13	3.13	9.38	9.38
	7-9	18.76	12.50	18.76	9.38
	10-12	65.63	75.01	71.88	81.26
76-77	0	0.00	0.00	0.00	0.00
	1-3	6.26	3.13	0.00	0.00
	4-6	0.00	3.13	0.00	0.00
	7-9	3.13	6.26	9.38	9.38
	10-12	90.63	87.51	90.64	90.63
77-78	0	12.50	9.38	3.13	3.13
	1-3	3.13	6.25	6.26	0.00
	4-6	15.63	0.00	9.38	6.26
	7-9	12.51	9.38	9.38	6.26
	10-12	56.25	75.01	71.88	84.38
78-79	0	6.25	3.13	0.00	0.00
	1-3	0.00	0.00	0.00	0.00
	4-6	0.00	3.13	0.00	0.00
	7-9	9.38	3.13	6.26	0.00
	10-12	84.38	90.63	93.76	100.01
79-80	0	0.00	0.00	0.00	0.00
	1-3	6.25	6.26	0.00	0.00
	4-6	3.13	0.00	0.00	0.00
	7-9	3.13	6.26	6.25	0.00
	10-12	87.50	87.51	93.76	100.00
80-81	0	3.13	3.13	0.00	0.00
	1-3	3.13	3.13	0.00	0.00
	4-6	3.13	0.00	6.26	0.00
	7-9	18.76	6.26	12.50	15.63
	10-12	71.88	87.50	81.26	84.39
81-82	0	0.00	0.00	0.00	0.00
	1-3	6.25	3.13	0.00	0.00
	4-6	12.50	9.38	15.64	15.63
	7-9	28.13	28.13	53.13	21.89
	10-12	53.13	59.38	31.25	62.51

OVERALL STATISTICS

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	0	4.81	2.41	0.24	0.24
MEDIAN	0	6.25	3.13	0.00	0.00
ST. D.	0	4.16	2.90	0.87	0.87

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	1-3	3.13	3.85	0.42	0.48
MEDIAN	1-3	3.13	3.13	0.00	0.00
ST. D.	1-3	2.55	3.86	1.74	1.18

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	4-6	5.05	2.65	6.01	4.09
MEDIAN	4-6	3.13	3.13	6.26	0.00
ST. D.	4-6	5.34	2.81	6.31	5.47

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	7-9	16.35	11.30	16.83	12.99
MEDIAN	7-9	9.39	9.38	12.50	9.38
ST. D.	7-9	15.10	8.61	14.74	11.82

STAT.	HPER	BAMODEL	BCMODEL	MUMODEL	MPMODEL
MEAN	10-12	70.68	79.82	76.45	82.22
MEDIAN	10-12	71.88	87.50	81.26	84.38
ST. D.	10-12	19.08	12.41	19.87	15.59

FWCA REPORT

APPENDIX K

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-317

FLORIDA GAME AND FRESH WATER FISH COMMISSION

C. TOM RAINEY, D.V.M. Miami | WILLIAM G. BOSTICK, JR. Winter Haven | DON WRIGHT Orlando | THOMAS L. HIRES, SR. Lake Wales | MRS. GILBERT W. HUMPHRI Miccosukee

ROBERT M. BRANTLY, Executive Director
ALLAN L. EGBERT, Ph.D., Assistant Executive Director

HARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, Florida 32399-1600
(904) 488-1960

RECEIVED
MAR 28 1990

March 22, 1990

Mr. David L. Ferrell
Field Supervisor
United States Department of the Interior
Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961-2676

Re: Modified Water Deliveries to Everglades National Park, Draft Fish and Wildlife Coordination Act Report

Dear Mr. Ferrell:

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed the referenced report, and offers the following comments in fulfillment of our responsibilities under the Fish and Wildlife Coordination Act.

This is one of the most thoughtfully prepared and exhaustively documented Coordination Act reports that we have reviewed. The intensive scrutiny of alternatives was necessitated by the finding that the original Basic Raindriven alternative to modify water deliveries to Everglades National Park would jeopardize the continued existence of the endangered snail kite. Thus, two new action alternatives, the Modified Raindriven and the Modified Minimum, were developed and compared with the Base (no-action) condition to assess their ability to improve ecological conditions in the southern Everglades (the ultimate goal of this Corps of Engineers project).

We concur with both the conclusions and recommendations of this report. We agree that the Modified Minimum delivery schedule should be adopted as the "interim operating schedule." It redistributes flows across the original width of Shark River Slough, while maintaining or improving habitat critical to snail kites, wood storks, alligators, and other everglades wildlife.

We concur with your recommendation to enlarge Structure 333 to enhance water delivery to Northeast Shark Slough, instead of delivering water across Conservation Area 3B to "restore sheetflow." Area 3B currently has excellent

Appendix K. Comments and concurre by Florida Game and Fresh Water Fish Commission.

Everglades wildlife values and good water quality. We would object to diverting the poorer quality water from the L-67 canal across Area 3B, since this action would degrade high-quality habitat. Only after the nutrient reduction goals of the Everglades SWIM Plan are reached would discharge across Area 3B be acceptable.

Fine-tuning to improve the water delivery to Everglades National Park will be required beyond the specific proposals currently under review in this public works project. One variation that should be modelled is use of a transition zone feature in the Modified Minimum alternative to reduce the potential for damage from sudden, excess flow deliveries through the S-12 structures when Area 3A exceeds schedule. For the longer term, investigation of a vegetated flow-way from Lake Okeechobee to the southern Everglades should be initiated. A flow-way could allow increased delivery of water with smoother transitions in timing, and could be a major feature for removal of nutrients emanating from the Everglades Agricultural Area.

Sincerely,

Robert M. Brantly

Colonel Robert M. Brantly
Executive Director

RMB/BSB/rs
ENV 2-1-1/5
cc: A. J. Salem, U.S.A.C.E.
Lt. Col. R. Daniel Dunford

D-319

FWCA REPORT

APPENDIX L

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-320

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
3500 Delwood Beach Road
Panama City, FL 32408

MAR 26 1990

March 23, 1990 F/SER113/MT

Mr. David Ferrell
Area Supervisor
U.S. Fish & Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

Dear Mr. Ferrell:

The National Marine Fisheries Service (NMFS) has reviewed your Preliminary Draft Fish and Wildlife Coordination Act Report as requested by your letter dated February 26,1990. Dr. Joan Browder of our Southeast Fisheries Center reviewed the report and a copy of her memo is enclosed for your information.

Generally, the NMFS concurs with the recommendations in the report, however, with one exception. As an interim plan, until the proposed structures can be built, all features of the Modified Raindriven Plan that can be operated without the proposed structures should be utilized.

We appreciate the opportunity to provide these comments. If you have any questions, you may contact Mr. Mark Thompson of my staff at 904/234-5061 or Dr. Joan Browder in the Miami Laboratory at 305/361-4270.

Sincerely yours,

W. Mark Thompson
for Edwin J. Keppner, Ph.D.
Area Office Supervisor

Encl.

cc:
F/SER1
J. Browder

Appendix L. Comments and concurrence by National Marine Fisheries Service.

D-321

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

March 20,1990

To: Mark Thompson

From: Joan Browder *Joan Browder*

Subject: Preliminary Draft Fish and Wildlife Coordination Act Report on the Modified Water Delivieries project for Everglades National Park.

I have reviewed the subject report from the standpoint of the principal interests of the National Marine Fisheries Service. These are the ecological health and productivity of South Florida coastal wetlands and estuaries inside and outside of Everglades National Park that act as nursery grounds and food-source areas for estuarine-dependent fishery species and their forage. Fishery species dependent upon South Florida coastal areas and estuaries include the commercially valuable pink shrimp and spotted seatrout and many recreationally important species, such as red drum, mangrove snapper, and spotted seatrout. The timing and quantity of freshwater inflow determines the basic characteristics of estuarine and coastal habitat. As an agency, we are principally interested in water management planning in the Florida Everglades as it affects freshwater flow to the coast. We believe that the health and productivity of South Florida estuaries can best be optimized by re-establishing a more natural total volume and temporal and spatial pattern of freshwater flow to the coast.

Three types of changes in the natural pattern of freshwater flow can damaging to South Florida estuaries. These are: (1) First, a decrease in dry season flow to estuaries, which can cause some locations with low rates of exchange with the ocean to become hypersaline. The extremely high salinities that often occur in northeast Florida Bay and north central Florida Bay may be due to a decrease in the historic flow to these areas. (2) Second, extreme high discharges, usually during the wet season, which cause rapid, extreme decreases in salinity and stress estuarine organisms. A dramatic example is the fish kill in Manatee Bay associated with the abrupt release of an extremely large volume of water from the C-111 canal. (3) A third, more subtle effect, may be caused by changes in the timing of flow to an estuary. Peak flows occurring in the fall may be beneficial, whereas, the same flow rates may be damaging, if coming in late winter and early spring, which is a peak time of immigration of many species of young larvae into these systems.

Although planning and negotiations concerning the Modified Water Deliveries did not specifically address problems in the estuary, we believe that some aspects of proposed projects might be beneficial to estuaries. Structural modifications that potentially could allow extreme high flows to be retarded upstream have potential benefit to estuaries, as do structural modifications that allow the more rapid release of water to estuaries during

D-322

periods of water scarcity. We should greatly favor structures that will allow greater flexibility in water routing and temporary storage.

According to the flow summary in Table 4 of the USFWS Coordination Act Report, the Modified Raindriven Plan can be expected to deliver more dry-season flow and more wet-season flow to the Park and its estuaries than any of the other three plans, including the basic raindriven plan. This makes it appear slightly more advantageous than the basic raindriven plan. Because releases are based on a rainfall-driven formula, the temporal pattern of flow to the estuary can be expected to better-approximate the natural pattern than would be expected under either the basic minimum flow or modified minimum-delivery plans.

We should concur with the U.S. Fish and Wildlife Service in recommending construction of the Modified Raindriven structures described in the U.S. Corps of Engineers Modified Water Delivery Plan. These structures include the six specified structures on the L-67a canal and levee and the three specified structures on the L-29 canal and levee. The main purpose of these structures is to allow a proportion of the total releases from Conservation Area 3A into the Park to be directed through the main natural flow-way of the Everglades, Northeast Shark Slough, by way of Conservation Area 3B. Construction of these structures will add needed flexibility to the system. Such added flexibility will allow the implementation of an optimum operating schedule, which will be developed over the next few years through experimentation, monitoring, and interaction among concerned government agencies.

The structures on L-67a are of two types. Structures S-345A, B, and C are openings in the L-67a levee that will allow water to flow from the L-67a canal into Water Conservation Area 3B. Structures S-349A, B, and C are gated structures in the L67a canal that can be used to retard the southward flow of water through the canal. Located just downstream from the S-345 structures, they potentially could increase the head to promote greater flow into WCA-3B. Furthermore, they potentially could be used to hold more water in the northern part of WCA-3A and prevent excessive discharges through the S-12 structures into the Park during periods of high-frequency, high-intensity rainfall. Such action might have benefits, not only by preventing excessively high water levels in the Park and excessively high discharges to estuaries during extreme wet periods, but also by extending flow to the estuaries into the dry season. In addition, by retaining more wet season-surplus in WCA-3A, such structures could retard dry-season fires. Although they will not be used under the Modified Raindriven Plan as presently formulated and agreed upon among agencies, the S-349A, B, and C structures add important flexibility to the system. They are adjustable gates that can be opened and closed according to season and conditions under some improved schedule to be agreed upon in the future. These gates could be very important in moderating the high discharges to the estuaries that are often experienced following high-intensity rainfall events. At a

minimum, these gates could be closed when the regulation stage has been reached at the S-12 structures. Other operating plans for these structures that would be beneficial to Everglades and estuarine ecosystems and would not jeopardize the snail kite seem feasible and should be the topic of future testing in models.

We should fully concur with the recommendation of the U.S. Fish and Wildlife Service that the S-333 structure in L-29 canal be enlarged to allow releases to the Park to be directed through NESS without having to pass through WCA-3B. This could be extremely useful during dry periods, when leakage toward the east coast through WCA-3B could be a concern. Leakage through WCA-3B probably is not a concern during wet periods, when the water table on the east coast ridge will be higher than that in WCA-3B and WCA-3B and seepage of water into WCA-3B rather than leakage from may occur. The enlargement of S-333 would be an important addition to the plan and would add considerable structural flexibility to the system to deliver water to the Park.

We should concur with USFWS in urging that immediate attention be given to the consideration and planning of a broad, vegetated flow-way through the Everglades Agricultural Area. Such a flow-way could improve water quality and increase the capacity for routing flood water from the EAA and Lake Okeechobee to the south. Both the SFWMD model and the University of Florida (C. Walters) model suggest that a much higher total annual volume of water flowed across the coastal boundary of Everglades National Park historically than it does presently. Full use of EAA water and excess Lake Okeechobee water could potentially restore near-natural flows to the Park and its estuaries.

Now that the SFWMD model has been modified to approximate the pre-development hydrologic system and the University of Florida hydrologic model exists, there is great potential in the near future to develop a successor to the modified raindriven plan now proposed. We recommend that an orderly procedure for proposing alternatives, modeling their potential effects, and monitoring biological indices of effects of current management policies be incorporated into the Modified Raindriven Plan.

I believe we should differ with the USFWS in one respect. I suggest that, as an interim plan until the proposed structures can be built, all features of the Modified Raindriven Plan that can be operated without the proposed structures be utilized. This includes movement of water from Lake Okeechobee into the southern end of WCA-3A, as necessary, to maintain a dry-season refuge for snail kites. This is a better alternative than the modified minimum plan, which, afterall, is no different than the basic raindriven plan until the structural change is made in L-67 extended (i.e., filling it in). Table 4 in the Coordination Act report suggests that, given the rainfall from 1969 through 1982, the Park and its estuaries would have received more water under the raindriven plan than under the minimum delivery schedule. Furthermore, because of the relationship of the schedule with

rainfall, the timing would have more nearly approximated the natural pattern. A plan based on rainfall seems to be progress in the right direction.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
3500 Delwood Beach Road
Panama City, FL 32408

April 3, 1990

RECEIVED
APR - 6

Mr. David Ferrell
Area Supervisor
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

Dear Mr. Ferrell:

After receiving questions from the U.S. Army Corps of Engineers, Jacksonville District, about our position on the Everglades General Design Memorandum, we feel it is necessary to further clarify our position. Speaking specifically to "recommendation 5" on page 37 of the Preliminary Draft Fish and Wildlife Coordination Act Report, we view both the "basic minimum delivery plan" and the "modified minimum delivery plan" as unacceptable for future use in the Everglades. We do not believe that the "modified minimum delivery plan" should be used in place of the "modified raindriven plan," either before or after the structures identified in the rainoriven plan are built. As we understand it, all the structures described and specified under the "basic raindriven plan" will be authorized and built under the "modified raindriven plan."

The Preliminary Coordination Report refers to a period after the structures are built "until...increased volumes of water are available to better take advantage of the new structures and to satisfy other needs...." During this period, the U.S. Fish and Wildlife Service recommends the use of the "modified minimum plan" rather than the "modified raindriven plan." The National Marine Fisheries Service does not support this recommendation. Instead, we recommend that the "modified raindriven plan" be used to the extent possible (subject to legal and physical constraints) in each stage of structure construction and after completion.

In our view, any form of the "minimum delivery system" is a step backward in efforts to establish a more natural spatial and temporal pattern of water flow to the Park and, subsequently, to restore the natural productivity of the Everglades and its estuaries. We view the "modified raindriven plan" as the best of the plans currently proposed and believe it should be adopted and immediately employed as operating policy in concept and utilized to the fullest extent possible within existing legal and physical constraints. We further urge that action be taken immediately to eliminate these constraints. Further, we urge continued design, modeling, monitoring, and negotiation to develop an improved rainfall-based delivery plan. The proposed structures will provide the necessary flexibility to adjust the operating plan toward an optimal solution.

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We appreciate the opportunity to provide these additional comments. If there are any further questions, please contact Mr. Mark Thompson of my staff at 904/234-5061 or Dr. Joan Browder in the Miami Laboratory at 305/361-4270.

Sincerely yours,

W. Mark Thompson

for Edwin J. Keppner, Ph.D.
Area Office Supervisor

cc:
F/SER1
J. Browder
J. Moulding, COE

D-327

FWCA REPORT

APPENDIX M

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-32B

M

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Blvd.
St. Petersburg, Florida 33702

August 6, 1990

RECEIVED
AUG - 8 1990

Mr. David Ferrell
Area Supervisor
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

Dear Mr. Ferrell:

Following are comments by the National Marine Fisheries Service on the recommendations presented in the Corps of Engineers' Everglades General Design Memorandum (GDM) and discussed in the Fish and Wildlife Coordination Act report. The recommendations we will comment upon are as follows: (1) construction of eight structures in the Everglades for increased flexibility in routing water to the Park and (2) interagency planning of a new operating plan for water releases to the Park.

The primary interest of the National Marine Fisheries Service in Modified Water Deliveries planning is to restore a more natural volume and timing of freshwater flow to South Florida estuaries. Estuaries provide nursery grounds for many fishery species and their forage. At least 95% of the weight of Gulf of Mexico landings is estuarine dependent. Many species harvested offshore spend their early life in estuaries, where habitat conditions determine survival and growth. In South Florida, recreationally or commercially important fishery species that depend upon estuaries include pink shrimp, blue crab, red drum, spotted seatrout, snook, and many more.

Florida Bay and other estuaries of Everglades National Park are important nursery grounds for pink shrimp harvested in the in the multimillion dollar Tortugas fishery. A generally declining trend in catch rates on the Tortugas grounds has been observed since the 1960s. Two independent studies based primarily on data from the 1960s and 1970s indicated that Tortugas landings were correlated with Everglades water levels, which are rough indicators of relative rates of freshwater runoff. Although exceptionally high catch rates occurred in the biological year 1981-82 (July-June), the low catch rates and landings of the past three years (1986-87, 1987-88, and 1988-89) are unprecedented. The recent death of extensive seagrass acreage in Florida Bay is another sign of the currently poor ecological health of Florida Bay.

The temporal and spatial pattern of freshwater inflow is a major factor influencing the ecological health and productivity of estuaries. Limited research in South Florida estuaries suggests

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that higher levels of productivity are maintained under natural patterns of freshwater flow. Natural flow patterns, in contrast to patterns changed by channelization to drain wetlands, are characterized by a lag of up to several months between peak rainfall and peak runoff, which moderates peak flows and prolongs base flow. Upstream water management activities have caused a disruption of the natural flow pattern in several respects. In addition to increasing the frequency of excessive discharges and reducing base flow, water management activities have changed spatial patterns, diverting flow away from some estuaries and into others. The result has been damaging both to the estuaries receiving more than their natural flow and to those receiving less. Even changes in the timing of inflow can be damaging. For instance, high flows may be beneficial in the fall, but damaging in late winter and early spring, which is the time of peak immigration of many species of young larvae into these systems.

Many South Florida estuaries have been degraded by changes in freshwater inflow patterns, however Manatee Bay and Northeast Florida Bay are two prominent examples. Manatee Bay is exposed intermittently to extremely high discharges, which depress salinities and retard mixing, killing many organisms and bottom vegetation. Northeastern Florida Bay is subject to chronic shortages of freshwater and resultant hypersalinity. Salinity measurements by Park researchers suggest that even western Florida Bay, which is one of the more oceanic parts of Florida Bay, can be affected by freshwater runoff.

Although planning and analyses concerning the Modified Water Deliveries have not specifically addressed problems in the estuaries, we believe that the eight proposed structures are absolutely essential to implementation of any operating strategy that restores a more natural timing and volume of runoff. The National Marine Fisheries Service strongly supports construction of the eight proposed structures, as described in the Corps GDM and in the Fish and Wildlife Coordination Act Report.

The main purpose of the eight structures is to allow a proportion of the total releases into the Park from Conservation Area 3A to be directed through the main natural flow-way of the Everglades, Northeast Shark Slough (NESS), by way of Water Conservation Area 3B. All eight structures contribute to this objective. The proposed new gates in L-67a (S-345A,B, and C) are openings in the L-67a levee and will restore the natural connection between WCA-3A and WCA-3B. The proposed gates in L-29 will reopen the natural flow route from WCA-3B into Northeast Shark Slough. The proposed adjustable weirs (S-349A,B, and C) are structures in the L67a canal that can be used to retard the southward flow of water through the canal and to enhance the movement of water into WCA-3B.

Although elimination of the L-67extended levee will allow

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water released through the S-12 structures to move into Northeast Shark Slough, we believe that this action alone would not restore the natural timing of freshwater flow through the lower Everglades and into the estuaries. Restoring the natural spatial pattern of flow through WCA-3B is more likely to restore the natural timing, expanding the flow period and decreasing peak flow.

The proposed adjustable gates in the L-67a canal are particularly important components of the proposed structural modifications. They will provide the ability to hold more water in the northern part of WCA-3A and to direct more water into WCA-3B. Retarding flow to the southern part of WCA-3A will reduce the frequency with which regulatory releases are made to the Park through the S-12 structures. Model tests by the Corps suggested that, had these structures been in place during operation of the experimental raindriven plan, they might have reduced the frequency with which the L31N canal had to be drawn down to prevent the water table in the Upper East Everglades from exceeding an upper threshhold agreed upon with residents and agriculturalists. This component of the experimental plan probably increased the frequency of high-volume releases to Manatee Bay through the C-111 canal. Because they can retard water movement to the downstream end of the system, the proposed adjustable gates in the L-67a canal could be very important in moderating the high discharges to the estuaries that are often experienced following high-intensity rainfall events.

We recognize the concern for "leakage" within WCA-3B and would like to comment on the leakage question. Since, water flow is driven by elevation differences in the water table, leakage through WCA-3B probably will not be problem during wet periods, because the water table on the east coast ridge will be higher than that in WCA-3B during this time. Water <u>seepage into WCA-3B</u> rather than leakage from WCA-3B probably occurs during the wet season.

Two general types of potential operating plans are described in the GDM and the Coordination Act Report: (1) minimum delivery plans and (2) raindriven plans. In our view, any form of the 'minimum delivery system' is a step backward in efforts to establish a more natural spatial and temporal pattern of water flow to the Park and, subsequently, to restore the natural productivity of the Everglades and its estuaries. We strongly recommend the use of a raindriven type of plan.

We believe that the concept of a raindriven plan is far superior to the minimum-plan concept in that it incorporates both the seasonal pattern and the year-to-year variability that are characteristic of the natural Everglades hydrology. However, a better algorithm relating water releases (into the Park) to rainfall probably can be found than the one presently in use as part of the experimental operating plan. The present algorithm is based on the relationship between rainfall and flow under the

D-331

Tamiamia Trail (Hwy 41) into the Park in the 1950s. The Everglades hydrologic system had already been greatly changed by that time. The water releases prescribed by the present raindrive algorithm may be insufficient to maintain ecologically healthy Everglades and estuaries. The insufficiency may be more disruptive to natural systems during low flow periods than during peak flow periods.

Now that the SFWMD model has been modified to approximate the pre-development hydrologic system and a University of Florida hydrologic model exists that also approximates the pre-development Everglades hydrologic system, the tools are in hand to develop a better raindriven plan. Although we may not be able to restore the total volume of natural flow to the Everglades and its estuaries, we may be able to identify and reproduce sufficient characteristics of that flow to restore much of the productivity of the Everglades and its estuaries.

Ecological research in Florida Bay and other Park estuaries, particularly Whitewater Bay, would help to understand the characteristics of freshwater flow that are most important to these systems. This type of research in the Park has been totally lacking.

We make several recommendations toward developing a future raindriven operating plan: (1) Establish an orderly procedure for proposing alternatives, modeling their potential effects, and monitoring biological indicators; (2) Add the coastal ridge, groundwater hydrology, and the C-111 area to the University of Florida model so that it can better approximate the entire system of interest; (3) Model freshwater flow into Florida Bay and other estuaries, specific to each coastal area, (4) Install a series of recording wells perpendicular to the coast at several locations within Everglades National Park and use stage data from these wells to calibrate the models; (5) Institute research in Florida Bay, Whitewater Bay, and other estuaries within the Park, as well as in Manatee Bay, that will provide a basis for testing the effects of various water management strategies on the estuarine systems; and (6) Adjust the operating strategy periodically to improve performance, based on continued monitoring and modeling. The proposed eight new structures will provide the necessary flexibility to adjust the operating plan toward an optimal solution.

We view the 'modified raindriven plan' as an acceptable temporary operating plan until a better plan can be formulated and accepted by involved agencies. From out standpoint, the 'basic raindriven plan' also is acceptable as a temporary operating plan.

We concur with the recommendation of the U.S. Fish and Wildlife Service that the S-333 structure in the L-29 canal (Tamiami Canal) be enlarged to allow releases to the Park to occasionally be directed through NESS without having to pass

through WCA-3B. This added flexibility could be useful during dry periods, when leakage toward the east coast through WCA-3B might be a concern. The enlargement of S-333 would be an important addition to the Plan and would add considerable structural flexibility to the system to deliver water to the Park.

We join USFWS in urging that immediate attention be given to planning a broad, vegetated flow way through the Everglades Agricultural Area. Such a flow way could improve water quality and increase the capacity for routing flood water south from the EAA and Lake Okeechobee. A flow way would prevent dumping to the St. Lucie and Caloosahatchee the high volume flood waters that, under natural circumstances, would flow through the Everglades.

Both the SFWMD model and a model developed at the University of Florida by Carl Walters suggest that a much higher total annual volume of water flowed across the coastal boundary of Everglades National Park historically than it does presently. Full use of excess EAA and Lake Okeechobee waters probably is essential to the restoration of near-natural flows to the Park and its estuaries, particularly given the increasing urban water demand.

We would like to point out the need for a legal basis for insuring that the Park will receive the water that is prescribed by any future raindriven plan and will not be left with only the water not used in some other part of the South Florida system. Some kind of flexible guarantee to protect the Park from expanded water use in South Florida should be a critical component of the raindriven policy that permanently replaces the minimum policy for supplying water to Everglades National Park.

Finally, because of the ultimate relevance of this issue to coastal marine fisheries, the National Marine Fisheries Service would like to be involved in the research and planning of future operations plans for water releases to Everglades National Park. Any questions about our comments should be addressed to Dr. Joan Browder (305-361-4270) or Mr. Mark Thompson (904-234-5061).

Sincerely,

Edwin J. Keppner

for Andreas Mager
Assistant Regional Director
Habitat Conservation Division

D-333

FWCA REPORT

APPENDIX N

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-334

FLORIDA GAME AND FRESH WATER FISH COMMISSION

WILLIAM G. BOSTICK, JR. Winter Haven
DON WRIGHT Orlando
THOMAS L. HIRES, SR. Lake Wales
MRS. GILBERT W. HUMPHREY Miccosukee
JOE MARLIN HILLIARD Clewiston

ROBERT M. BRANTLY, Executive Director
ALLAN L. EGBERT, Ph.D., Assistant Executive Director

110 43rd Avenue, S. W.
Vero Beach, Florida 32968
July 23, 1990

RECEIVED
JUL 30 1990

Mr. David L. Ferrell
Field Supervisor
United States Department of the Interior
Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961-2676

Re: Modified Water Deliveries to Everglades National Park, Draft Fish and Wildlife Coordination Act Report (Revised)

Dear Mr. Ferrell:

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed the revised version of the referenced document, and finds that the concerns and recommendations stated in our 22 March 1990 letter on the original draft report remain applicable. While the revised draft is unclear as to which water delivery alternative is supported by the Fish and Wildlife Service, we continue to recommend that a modified version of the Modified Minimum delivery schedule be adopted as the interim operating schedule.

Sincerely,

Brian Barnett

Brian S. Barnett
South Florida Section Leader

BSB/rs
ENV 2-1-1/5

D-335

FWCA REPORT

APPENDIX O

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-336

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

February 4, 1991

REPLY TO
ATTENTION OF

Environmental Resources Branch
Planning Division

Mr. David L. Ferrell
Field Supervisor
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

Dear Mr. Ferrell:

This provides new information on the recommended plan of Modified Water Deliveries to Everglades National Park for your use in preparing the final Fish and Wildlife Coordination Act (FWCA) Report. The following changes have been made subsequent to public coordination of the draft EIS.

1. Relocation of the S-349/S-345 structures in the L-67A canal and levee.

2. Provision of a small-boat navigation access channel around each of the S-349 structures.

3. Re-design of the 8 1/2 sq. mi. residential area flood mitigation features to up-size the S-357 pump station to 533 cfs and relocate it next to the L-31(N) canal, and to delete the Howard Drive internal conveyance canal.

Our analysis indicates that because of the minor hydrologic effects of these design changes, there would not be any significant change in the impacts on fish and wildlife resources or endangered species discussed in the DEIS. The details of our evaluation are included on the enclosed sheet.

We would like your final FWCA Report by the end of February, if at all possible, so we can include it with the FEIS for review by our higher authority. If it is not possible to meet this schedule because of a need for further review by your cooperating agencies, please provide us a preliminary final report for our in-house review when available. We must have the final report before we can initiate public coordination of the FEIS. To allow us to stay on schedule, we must receive this by 1 April 1991.

Sincerely,

A. J. Salem

A. J. Salem
Chief, Planning Division

Encl

D-337

CESAJ-PD-ES 4 February 1991

Evaluation of Design Changes in the Recommended Plan
GDM - Modified Water Deliveries to Everglades National Park

Relocation of L-67A Structures. At the suggestion of the Park and EPA, the S-349/S-345 structures have been moved farther apart along L-67A. In terms of distances along the levee, structures A, B, and C are now located approximately 15.9, 12, and 8.9 miles north from the Tamiami Trail, respectively. This compares with the original locations of 14.3, 13.1, and 12 miles, respectively. The new "B" structure location is the same as the original "C" structure. This places them in only one different grid cell of the Hydrologic Model as shown in Table 1 below.

Table 1

	Grid Cell Coordinates (x,y)	
Structure	New Location	Original Location
S-349A	24,28	24,28
S-349B	23,27	24,27
S-349C	22,26	23,27

Environmental Effects of Relocation. The Hydrologic Model would not be sensitive to these slight changes because of the size of the grid cells and way it handles discharge through structures. The greater spacing is expected to provide a somewhat more natural spread and distribution of water within WCA 3B. It would not affect the distribution of water within WCA 3A or the volume or timing of water released from WCA 3A because the flat topography along this reach of the canal would preclude any change in the original headwater-tailwater relationships across the S-345 structures.

Design of Navigational Access in L-67A Canal. A small boat bypass channel is proposed to be constructed around each of the 1000-foot long interceptor levees extending out from the S-349 structures into the WCA 3A marsh as shown in Figure 1. The channels are dimensioned for a design boat with length of 17 feet, 6-foot beam, and draft of about 2.5 feet when off-plane. This corresponds to the typical bass boats used by fishermen in the canal. The channels would have a bottom width of 24 feet at a design elevation of 4.0 feet NGVD. The top width at marsh elevation (7.0 feet NGVD) would be approximately 42 feet (3H:1V sideslopes). The channels would have an 85-foot radius of bend around the end of each levee to provide a safe line of sight for oncoming boats. Each bypass channel is about 2850 feet long, 500 feet of which will lie within the existing 100-foot wide berm on the west side of the L-67A canal.

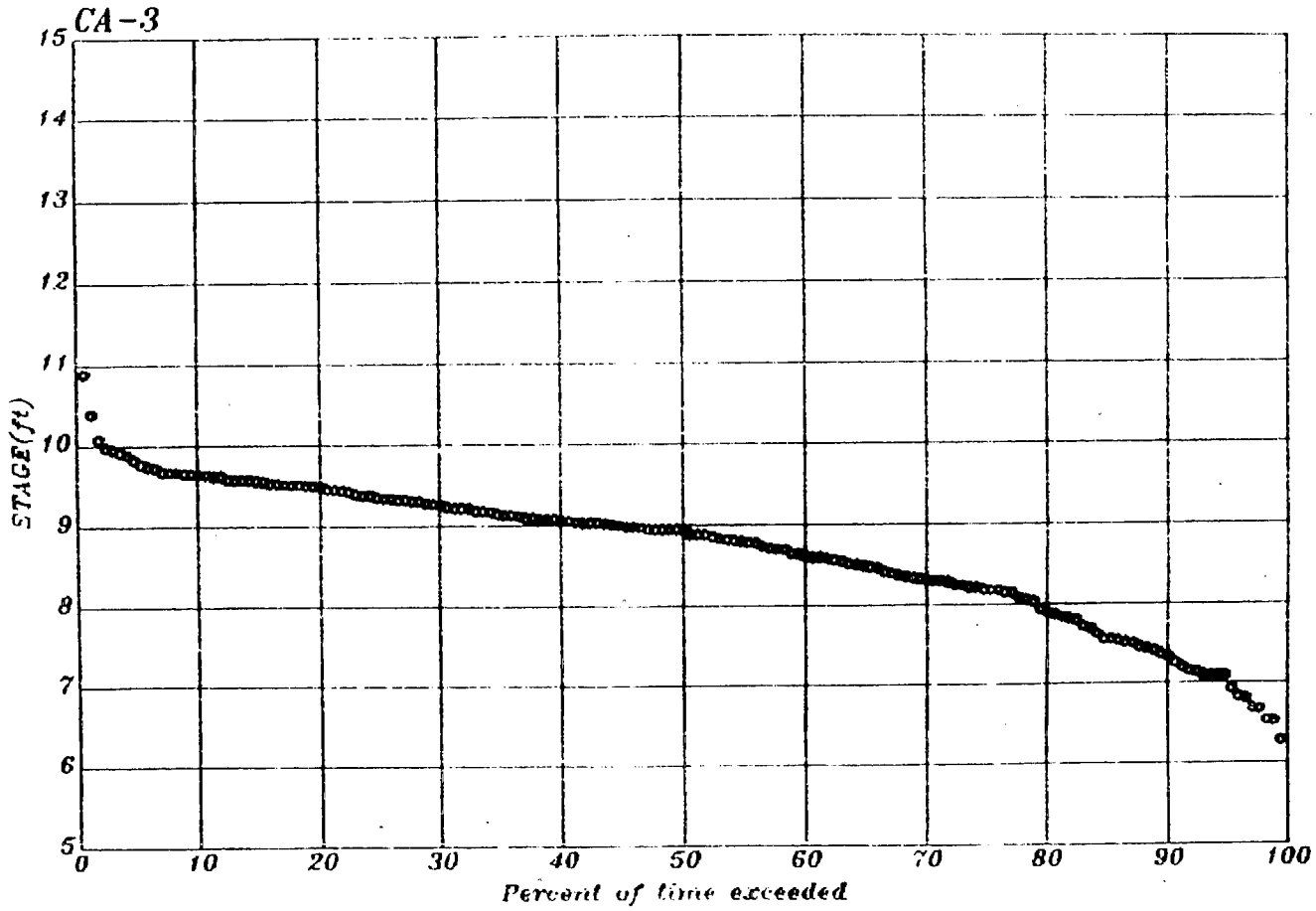
D-338

Environmental Impacts of Bypass Channels. The channels would be constructed by use of a drag-line dredge, and the material placed on the adjacent levee. No blasting is anticipated even if rock is encountered. Approximately 7 acres of Everglades marsh would be lost as a result of the three channels. Hydrologically, the channels would allow an insignificantly small volume of water to run around the S-349 structures when the structures are closed. This would not have any effect on the MRD Operational Plan because that plan calls for the structures to always be open. It would also not have any significant effects for potential future plans on the ability to redistribute water in WCA 3A, or to convey water into WCA 3B.

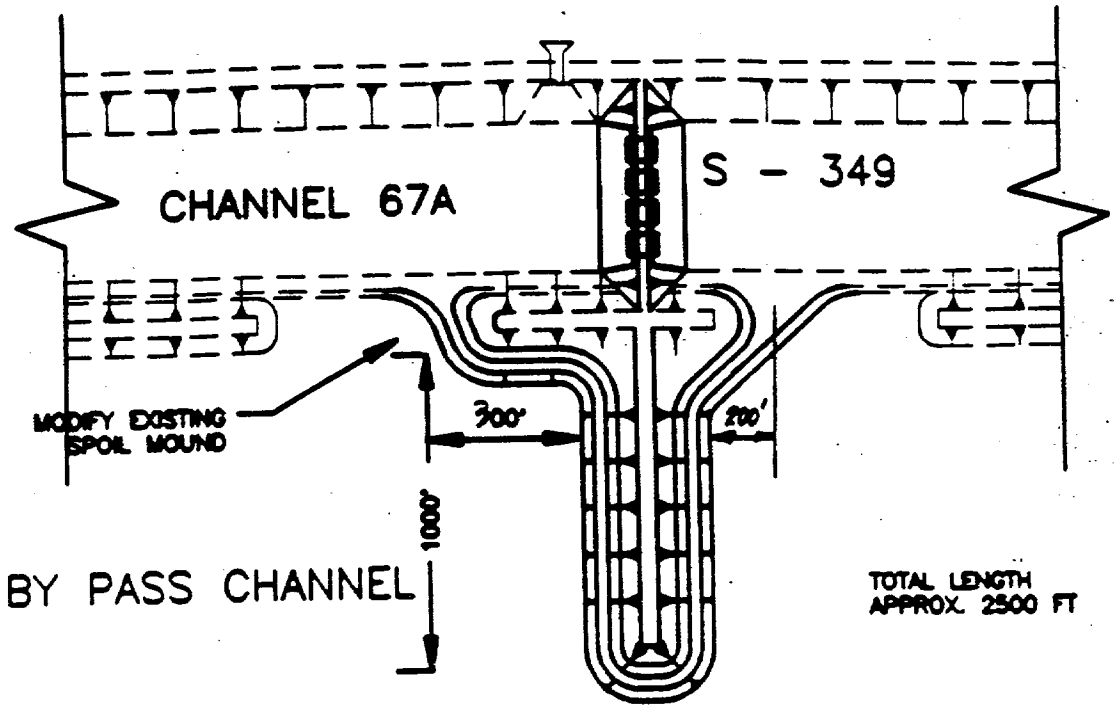
Impacts on Navigation. The bypass channels would allow boat access to the entirety of the L-67A Canal. Additional fishing opportunities would result along the new channels, and under most conditions additional access to open-water areas of the marsh would be possible. The SFWMD would be responsible for maintaining the channels free of aquatic weed impediments to navigation. As part of the aquatic plant control program, the SFWMD will be asked to also keep free of weed impediments several of the existing cutouts through the L-67A Canal berm as selected by the FGFWFC. This would provide boaters with improved fishing and hunting access at prime locations along the canal. From Figure 2., which shows model-predicted canal/channel stage under the MRD Operational Plan, average (50% excedance) channel depth would be about 5 feet. Only when canal stages drop below the marsh elevation of 7 feet NGVD would the design boats not be able to navigate through. This condition is predicted to occur with no more than 5% frequency. The channels are designed for two-way, slow/idle speed operation, and will be so signed. At an idle speed of 5 mph, a boat would require an additional 6 minutes to get past each of the L-67A Canal structures. As a result of spreading the S-349 structures farther apart, an additional 3.1 miles of the southern end of the L-67C Canal will be blocked from navigation by the containment levees of the conveyance canal that extends from S-345C through the pocket. There is no way to circumvent this impact without significantly diminishing project objectives.

Environmental Impacts of Changes Associated with the Pump Station. The changes within the 8 1/2 sq. mi. residential area would have no effect on fish and wildlife resources since this area is subject to build-out in the predicted with-project future.

RAIN-DRIVEN WATER DELIVERIES TO ENP
MODIFIED PLAN



A-340



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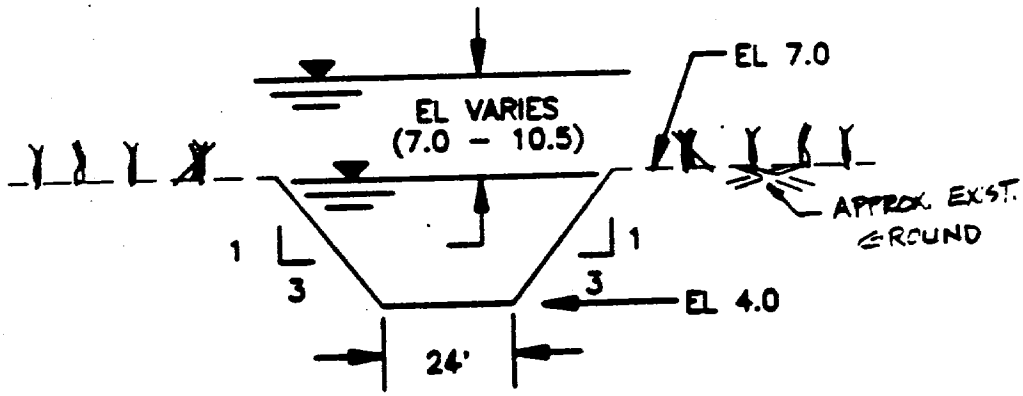

BY PASS CHANNEL
SECTION

BY-PASS CHANNEL ALTERNATIVE

TOTAL OF THREE
ONLY ONE SHOWN

FWCA REPORT

APPENDIX P

FINAL
ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

D-342

FLORIDA GAME AND FRESH WATER FISH COMMISSION

WILLIAM G. BOSTICK, JR. Winter Haven · DON WRIGHT Orlando · THOMAS L. HIRES, SR. Lake Wales · MRS. GILBERT W. HUMPHREY Miccosukee · JOE MARLIN HILLIARD Clewiston

ROBERT M. BRANTLY, Executive Director
ALLAN L. EGBERT, Ph.D., Assistant Executive Director

110 43rd Avenue, S. W.
Vero Beach, Florida 32968
March 5, 1991

CE
MAR 06

Mr. David L. Ferrell
Field Supervisor
U.S. Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961-2676

RE: Changes in the recommended plan of Modified Water Deliveries to Everglades National Park

Dear Mr. Ferrell:

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed the U.S. Army Corps of Engineers proposed changes to the recommended plan of Modified Water Deliveries to Everglades National Park. The following comments are provided to assist you in the preparation of the final Fish and Wildlife Coordination Act Report.

Three changes in the plan have been proposed.

1. The proposed S-349/S-345 structures in the L-67A canal and levee have been relocated. The three structures would now be spaced further apart, along a 7-mile reach of canal instead of a 2.2-mile reach.

2. A small-boat navigation access channel would be constructed around the 1,000-foot-long interceptor levee associated with each of the S-349 structures.

3. The flood mitigation features for the 8 1/2-square-mile residential area have been redesigned.

Only the first two of these changes would be of concern to our agency. A primary reason for our advocacy of the Modified Minimum plan was that it did not involve routing flood control canal water across Water Conservation Area 3B, which may be the most pristine example of Everglades remaining in the system. The Corps of Engineers opted for the Modified Raindriven plan, involving construction of the S-349/S-345 structures to divert water from the L-67A canal across the levees into Water Conservation Area 3B. Our concerns with this proposal were outlined in our 19 October 1990 comments (enclosed) on the draft GDM and EIS, and these remain applicable. The revised locations for the S-349/S-

D-343

345 structures will eliminate fisherman access to another 3.1 miles of the L-67C canal, making more than half the canal inaccessible. The Corps decision to provide navigation channels around the L-67A structures and interceptor levees will provide a means, albeit inconvenient, for boaters to retain access throughout this popular fishing area. The fisherman are understandably unhappy with these adverse impacts on recreational use.

Sincerely,

Brian Barnett

Brian S. Barnett
South Florida Section Leader
Office of Environmental Services

BSB/rs
ENV 1-3-2
Enclosure
CC: Mr. Jon Moulding
Environmental Resources Branch
Planning Division
U.S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Colonel R. Dan Dunford
Regional Manager, Everglades Region
Florida Game and Fresh Water Fish Commission
551 N. Military Trail
West Palm Beach, Florida 33415

FLORIDA GAME AND FRESH WATER FISH COMMISSION

WILLIAM G. BOSTICK, JR. Winter Haven | DON WRIGHT Orlando | THOMAS L. HIRES, SR. Lake Wales | MRS. GILBERT W. HUMPHREY Miccosukee | JOE MARLIN HILLIARD Clewiston

ROBERT M. BRANTLY, Executive Director
ALLAN L. EGBERT, Ph.D., Assistant Executive Director

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, Florida 32399-1600
(904) 488-1960

October 19, 1990

Ms. Karen MacFarland, Director
Florida State Clearinghouse
Executive Office of the Governor
Office of Planning and Budgeting
The Capitol
Tallahassee, Florida 32399-0001

RE: SAI #FL9008080208C, Modified Water Deliveries to Everglades National Park, Draft GDM and EIS

RECEIVED OCT

Dear Ms. MacFarland:

The Florida Game and Fresh Water Fish Commission has reviewed the referenced documents, and offers the following comments.

The goal of this project is to improve water deliveries to Everglades National Park (ENP), via structural changes in the Central and Southern Florida water management system, to more naturally distribute the inflow across Shark River Slough. An interim operating plan based on rainfall-driven deliveries has been developed, but the ultimate operational strategy will presumably be defined over the next few years.

The Game and Fresh Water Fish Commission fully supports the goal of redistribution of inflows to ENP across the full width of Shark River Slough. This measure, in concert with ENP acquisition of Northeast Shark River Slough, will begin the critical process of hydrological restoration required for the survival of ENP's unique natural resources.

We are, however, concerned with certain aspects of this project that could adversely impact Conservation Area 3B (CA3B) and seriously interfere with recreational use of L67A. The plan calls for a portion of the water going to Northeast Shark River Slough (approximately 24%) to be delivered via sheet flow across Water Conservation Area 3B (CA3B). This would be accomplished by placing three structures (S-345 A, B, & C) across the L-67A

D-345

canal to back up canal flows and force water through culverts in the levees separating CA3A from CA3B. The rationale for this proposal is the restoration of a more natural sheetflow condition in CA3B, which is nearly isolated from the remainder of the water management system and is currently supplied mostly by rainfall. The GDM and EIS refer to "ecological restoration of CA3B" which would take place with the flow-through system, although no data are presented to support this conclusion. In fact, CA3B may be the most pristine example of Everglades remaining in the system, precisely because it has been isolated. It has excellent Everglades wildlife habitat and good water quality.

If diversion across CA3B is to occur, it must not adversely change the hydrology or degrade the water quality currently existing in this area. The models predict minimal hydrological impact, but, to prevent any future possibility of adverse changes, an ecosystem-based regulation schedule should be developed for CA3B. Water quality data from the South Florida Water Management District reveal that phosphorus concentrations in the L-67A canal tend to be lower during the higher water stages when the S-345 structures would be utilized. However, they are still considerably higher than background marsh values, and we are concerned about the potential for adverse ecological shifts in CA3B due to diversion from L-67A. If the Corps of Engineers proceeds with this diversion across CA3B, we strongly recommend that it be done only when water quality in L-67A approaches that of the background levels in CA3B marsh. If this is not possible, we recommend that all water be delivered to Northeast Shark River Slough through structure S-333 (at the south end of L-67A) and L-29 (this mode of delivery would supply 78% of the volume under the proposed plan).

Another concern we have with this portion of the project is the impact of the three S-345 structures on recreational use of the L-67A canal. As presently designed, the structures would block all boat traffic in the canal, isolating boaters to the areas north, or south, of the three structures. The L-67A canal is the most popular fishing area in the Everglades, with 100 to 200 boats present on a busy weekend day. A preliminary survey conducted in 1988 revealed that approximately 200,000 man/hours of fishing took place in L-67A during the late winter-early spring prime fishing period. Boaters routinely access the entire length of this canal, whether they launch at the north or south ends. The structures, as proposed, would seriously interfere with this recreational use.

If the diversion of water across CA3B can meet the recommended water quality criteria described above and the Corps of Engineers proceeds with this option, we recommend that any structures constructed in L-67A not be permanent impediments to boat traffic. Our first choice would be that no canal-blocking structures be built, but that water be routed from CA3A to CA3B through a

series of culverts in the L-67 levees. If structures are built, they should include openings, or notches, for boat access or, as a last resort, bypass channels.

Sincerely,

Robert M. Brantly

Colonel Robert M. Brantly
Executive Director

RMB/BSB/rs
ENV 1-3-2
cc: A. J. Salem
Chief, Planning Division
U. S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0012

Lt. Colonel Robert D. Dunford, GFC, West Palm Beach

D-347

EIS APPENDIX E

CLEAN WATER ACT
404(B)(1) EVALUATION

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK
Central and Southern Florida Project
Part 1, Supplement 54

25 October 1991

SECTION 404(b)(1) EVALUATION REPORT
GDM on MODIFIED WATER DELIVERIES TO ENP

I. Project description.

a. Location. The discharge of dredged material will occur in Water Conservation Area 3 (WCA No. 3) in Everglades National Park (Park) and in Northeast Shark River Slough (NESRS), Dade County, Florida.

b. General Description. In WCA No. 3, eight gated structures will be constructed to allow conveyance of water from WCA No. 3A to WCA No. 3B and thence to NESRS. Also a pump station in the L-29 Canal. Associated with these structures will be conveyance and collection canals, and containment and tieback levees. In NESRS, a ring levee system will be constructed around a residential area immediately west of L-31(N). In the Park, the L-67 ext. canal will be back-filled using material from the adjacent levee.

c. Authority and Purpose. The GDM was authorized for the purpose of considering redistribution of water to the Park in order to improve ecological conditions.

d. General Description of Dredged or Fill Material.

(1) General Characteristics of Material. The fill is dredged material that will be taken in situ, consisting of varying proportions of marl, peat, and oolite rock.

(2) Quantity of Material. See Table 10 in the EIS.

(3) Source of Material. The fill material will be obtained in situ from existing levees or dredging in wetlands.

e. Description of the Proposed Discharge Site(s).

(1) Location. The fill will be located in WCA No. 3, ENP, and NESRS (See EIS Figure 1.)

(2) Size. See Table 10 in the EIS.

(3) Type of Site. The discharge sites are freshwater wetlands.

(4) Type(s) of Habitat. The WCA and NESRS habitat consists of wet prairies, the ENP habitat is a manmade open water canal.

(5) Timing and Duration of Discharge. During the years 1992-1997.

f. Description of Disposal Method. A combination of a drag line dredge and front-end loaders would be used to handle the fill material.

II. Factual Determinations.

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. The existing substrate is at a level elevation between 6 and 9 feet NGVD.

(2) Sediment Type. The sediment is either marl or peat and is essentially identical to the substrate at the fill area or adjacent to canals.

(3) Dredged/fill Material Movement. The material will not move once in place.

(4) Physical Effects on Benthos. Benthos in the L-67 ext. canal will be eliminated by the fill.

(5) Other Effects. None

(6) Actions Taken to Minimize Impacts. Fill is part of environmental restoration. Project dimensions are the minimum required to achieve restoration objectives. Levee slopes will be stabilized with mulch and/or grass seeding to control erosion and sedimentation.

b. Water Circulation, Fluctuation, and Salinity Determinations.

(1) Water. Objective is to restore natural hydrology.

(2) Current Patterns and Circulation. Not applicable.

(3) Normal Water Level Fluctuations. Objective is to restore natural hydrology.

(4) Salinity Gradients. Not applicable

(5) Actions That Will be Taken to Minimize Impacts. Fill is part of environmental restoration. Project dimensions are the minimum required to achieve restoration objectives. Levee slopes will be stabilized with mulch and/or grass seeding to control erosion and sedimentation.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site. Not applicable.

(2) Effects on Chemical and Physical Properties of the Water Column. Not applicable.

a) Light Penetration. Not applicable.

(b) Dissolved Oxygen. Not applicable.

(c) Toxic Metals and Organics. Not applicable.

(d) Pathogens. Not applicable.

(e) Aesthetics. Not applicable.

(3) Effects on Biota.

(a) Primary Production and Photosynthesis. All primary production in the open canal water in the Park will be lost and replaced with primary production from a like area of sawgrass community that will become established on the fill and on an additional area that will become established on the levee site when it is removed, resulting in a net gain in photosynthesis. In WCA No. 3 and NESRS, sawgrass productivity will be lost through dredge and fill and replaced with open water, resulting in a net loss.

(b) Suspension/Filter Feeders. All such biota will be lost in the fill areas and become established in the open water dredged areas.

(c) Sight Feeders. Those that are highly motile such as fish and reptiles would relocate to avoid the fill. Other, slow moving forms would be buried by the fill.

(4) Actions Taken to Minimize Impacts. Any blasting during construction would be conducted outside the nesting period of potentially sensitive species.

d. Contaminant Determinations. There will be no contamination from the fill material since it is all of in situ origin.

e. Effects on Aquatic Ecosystem and Organism Determinations. The aquatic ecosystem in canals will be replaced with wetland conditions in which wetland ecosystems will become established. Levees will constitute dry land habitats, replacing wetland habitats.

(1) Plankton. Canal fill will eliminate all plankton.

(2) Benthos. Canal fill will bury all benthos.

(3) Nekton. Canal fill will eliminate all nekton.

(4) Aquatic Foodweb. Open water community will be replaced by marsh community.

(5) Special Aquatic Sites.

(a) Sanctuaries and Refuges. Environmental restoration of Everglades National Park.

(b) Wetlands. Restoration.

(c) Mud Flats. Not applicable

(d) Vegetated Shallows. Restoration.

(e) Coral Reefs. Not applicable

(f) Riffle and Pool Complexes. Not applicable.

(6) Threatened and Endangered Species. The proposed fill will have no adverse effects on any listed species. The open water dredged areas would likely benefit the snail kite by improving feeding habitat.

(7) Other Wildlife. Habitat will be restored.

(8) Actions Taken to Minimize Impacts. Fill is part of environmental restoration. Project dimensions are the minimum required to achieve restoration objectives. Levee slopes will be stabilized with mulch and/or grass seeding to control erosion and sedimentation.

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. Not applicable.

(2) Determination of Compliance with Applicable Water Quality Standards. The discharge of fill materials will not violate or exceed State water quality standards for the Class III waters of WCA No. 3 and NESRS nor the Outstanding Waters of National Significance (OWNS) occurring in the Park. Therefore, Water Quality Certification is likely to be granted.

(3) Potential Effects on Human Use Characteristics.

(a) Municipal and Private Water Supplies. No sources of municipal or private water are located in or near the project area; thus, the placement of fill materials will not have an impact on these resources.

(b) Recreational and Commercial Fisheries. There would be no adverse effect on recreational fisheries. There is no commercial fishing in the area.

(c) Water-Related Recreation. The structures placed in the L-67A Canal will diminish somewhat the existing conveniences associated with recreational fishing in the L-67A Canals. Fishing opportunities in the L-67C Canal will be substantially reduced.

(d) Aesthetics. There will be a short-term decline in aesthetic values during construction. The fill in the Park will restore a natural wetlands vista along a 10-mile linear strip. The fill in WCA No. 3 will change a 1.4 mile linear strip of wetlands to a canal and levee vista. The structures in the L-29 levee will extend above the horizon and be visible for miles.

(e) Parks, National and Historic Monuments, National Wilderness Areas, Research Sites, and Similar Preserves. The fill in the Park will restore natural aesthetic qualities.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. The proposed discharge of fill materials in NESRS will allow an improvement in the hydrology of the remainder of the aquatic ecosystem. The Fill in WCA No. 3 and the Park will result in an improvement in the ecological functioning of the aquatic ecosystems.

h. Determination of Secondary Effects on the Aquatic Ecosystem. The fill in WCA No. 3 and the Park will result in an improvement in the ecological functioning of the aquatic ecosystems.

III. Findings of Compliance or Non-Compliance with the Restrictions on Discharge.

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States. Without excavation in wetlands, water-control structures and canals could not be built, and consequently, water movement could not be changed. Without fill for levees, water could not be directed into WCA No. 3B, and necessary residential flood mitigation could not be provided at practical cost.

c. The discharge of fill materials will not cause or contribute to, after consideration of disposal site dilution and dispersion, violations of any applicable State water quality standards for Outstanding Waters of National Significance or Class III waters.

d. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

e. The placement of fill material will not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any Critical Habitat as specified by the Endangered Species Act of 1973, as amended.

f. The placement of fill materials will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, and shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity; productivity and stability; and recreational, aesthetic, and economic values will not occur.

g. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem.

h. On the basis of the guidelines, the proposed disposal sites for the discharge of dredged or fill material is specified as complying with the requirements of these guidelines.

EIS APPENDIX F

RESPONSES TO PUBLIC COMMENTS ON DEIS

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK

Central and Southern Florida Project

Part 1, Supplement 54

U.S. Department of Housing and Urban Development
Atlanta Regional Office, Region IV
Richard B Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303-3388

August 16, 1990

Mr. A. J. Salem
Chief, Planning Division
Environmental Resources Branch
Department of the Army
Jacksonville District Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

This refers to your Memorandum dated August 1, 1990, transmitting the General Design Memorandum on Modified Water Deliveries to Everglades National Park and the Draft Environmental Impact Statement (DEIS).

Our review indicates there will be no significant adverse impact on any HUD programs as a result of this project.

Thank you for the opportunity to review and comment on your proposed project.

Very truly yours,

Ivar O. Iverson
Regional Environmental Clearance
Officer

US Department of Transportation
Federal Highway Administration

Florida Division Office

227 N Bronough St
Room 2018
Tallahassee, Florida 32301

August 17, 1990

IN REPLY REFER TO: HEC-FL

Mr. A. J. Salem, Chief, Planning Division
Jacksonville District, Corps of Engineers
Department of the Army
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

Subject: Florida - "Modified Water Deliveries to Everglades National Park," Draft Environmental Impact Statement

The subject document, transmitted by your August 1 letter, has been reviewed by this office. We offer the following comments for your consideration:

(1) The Florida Department of Transportation (FDOT) is developing projects for the multilaning and expansion of US-41 Tamiami Trail in west Miami. The raising of the grade on US-41 in the vicinity of L-31N should be coordinated with the FDOT to assure there will be no conflicts. Bids will be taken on August 29, 1990, for the widening and resurfacing of US-41 from the Collier County Line to SR-27, which includes the area involving the grade change. The project does not provide for this grade change.

(2) Likewise, FDOT is developing a project for the multilaning of US-1 from south of Homestead to Key Largo. This project will involve crossing the C-111 Canal. FDOT's project is presently in the environmental document stage, with the Draft Environmental Impact Statement out for comments. As cross drains under US-1 and sheet flow are of vital concern to the US-1 project, close coordination between your department and the FDOT will assist in obtaining an environmentally acceptable project.

We appreciate the opportunity to review and provide comments on the subject project.

Sincerely yours,

J. R. Skinner
Division Administrator
for

RESPONSES TO

U.S. Depart. of Transportation — Letter of August 17, 1990

1. Close coordination with FDOT will be sought during the FDM.

2. Coordination will be conducted in conjunction with our C-111 GDM.

FLORIDA DEPARTMENT OF STATE
Jim Smith
Secretary of State
DIVISION OF HISTORICAL RESOURCES
R.A. Gray Building
500 South Bronough
Tallahassee, Florida 32399-0250
Director's Office (904) 488-1480
Telecopier Number (FAX) (904) 488-1353

August 28, 1990

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

In Reply Refer To:
Robert C. Taylor
Historic Preservation
Planner
(904) 487-2333
Project File No. 902291

Attention: Planning Division
Environmental Resources Branch

RE: General Design Memorandum and Draft Environmental Impact Statement (GDM/DEIS); Modified Water Deliveries to the Everglades National Park in Dade and Monroe Counties, Florida

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Protection of Historic Properties"), we have reviewed the above referenced GDM/DEIS for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. The authority for this procedure is the National Historic Preservation Act of 1966 (Public Law 89-665), as amended.

Due to the high number of archaeological sites known for the area, the construction phase of the project should be carefully evaluated to assure that no unrecorded archaeological sites are adversely affected before being properly assessed as to their significance. Our review indicates that no significant historic structures will be affected by the project.

We note on page EIS-34 of the DEIS, Part 1, Supplement 54, under Section 4.41, Effects on Cultural Resources, that construction will be designed to avoid areas known to have a high probability of containing archaeological sites. If such areas are to be affected by the implementation of the plan, the ACOE will conduct a professional cultural resources survey prior to construction.

Therefore, conditioned upon the ACOE appropriately avoiding or mitigating project impacts to any identified significant archaeological sites, the proposed project will have no effect on sites

listed, or eligible for listing, in the *National Register of Historic Places*, or otherwise of national, state, or local significance.

If you have any questions concerning our comments, please do not hesitate to contact us. Your interest in protecting Florida's archaeological and historical resources is appreciated.

Sincerely,

Suzanne P. Walker
for George W. Percy, Director
Division of Historical Resources
and
State Historic Preservation Officer

GWP/rt

F.A.D.E.
Fishermen Against the Destruction of the Environment
7120 S.W. 58 Street
Miami, Florida 33143
(305) 665-9478

Tom Cunard, President

September 4, 1990

Colonel Bruce A. Malson
US Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

COPY: Mr. Jon Moulding

REFERENCE: Modified Water Deliveries to Everglades National Park

Dear Colonel Malson:

We are in receipt of the above referenced report and find your conclusion or recommendation totally unacceptable. F.A.D.E. is an association comprised of South Florida fishermen, sportsmen and environmentalists. F.A.D.E. in conjunction with all the area fishing clubs, fishermen, sportsmen, tackle retailers and businesses affected in Dade and Broward Counties object to the Modified Rain-Driven alternative that you have recommended. The Modified Rain-Driven system places three spillways and three culverts in one of the prime fishing areas left in South Florida. It restricts our access from Everglades Holiday Park south and from US-41 and the L-67A canal north, as well as the L-67C canal. (1)

In reviewing your extensive studies, I find no mention of recreational and business interest included. It seems poor planning not to include an affected multitude of people. I understand that you sent a release, J.D. No. 42-90, on August 2, 1990 to interested parties. Please be informed that we heard about it on August 21. This really cuts back on our response time of September 24th, regarding this review. (2)

The only alternative plan that we will accept at present, of the five suggested, is the Minimum Modified Delivery alternative. Which simply allows water from the L-67A canal to flow through the S-333 spillway, blocks the L-67 Extension canal, de-grades the L-67 Extension canal levee, modifies the S-334 spillway and allows the water to flow under US-41. We do not agree with any structures being built across the L-67 canal that restrict navigation. By navigation we mean boats over 2500 pounds that cannot be physically be carried over the structures. We are also opposed to the idea of building ramps between the spillways as an alternative.

It is our joint belief, that your Modified Rain Driven alternative will turn WCA-3B into a septic tank as has already happened in WCA-3A. Our Water Conservation Areas are not the dumping grounds for all the dirty water coming from the Everglades Agricultural Area. Clean the water at its source. Everyone knows were the source is! WCA-3B is in pristine condition and we would like to keep it that way. (3)

We formally request an extension beyond your September 24, 1990 deadline in order to further study the tremendous impact of your recommendation.

RESPONSES TO

Fishermen Against the Destruction of the Environment (F.A.D.E.) — Letter of September 4, 1990

1. The new issue raised by you and others regarding navigation access in the L 67A Canal is now addressed in FEIS paragraphs 3.13 and 4.41. In summary, small boat bypass channels around each of the S-349 structures have been incorporated into the recommended plan to allow boating access throughout the entire length of the L-67A Canal.

2. A 5-week extension in the comment period was granted.

3. Development and implementation of the SFWMD's Everglades SWIM plan is expected over the next 10 years to solve any water quality problems from the EAA. However, to ensure that the water discharged into WCA 3B through the S-345 structures is of good quality in the interim period, criteria for one or more water quality constituents will be established during Operational Strategy planning over the next several years. These criteria would be applied on a "real time" basis to govern the operation of the structures into WCA 3B, and will be consistent with the Everglades SWIM Plan and the results of the U.S. vs SFWMD. When the water stages in WCA 3A call for opening the S-345 structures, measured water quality at that time will have to meet the established criteria before the structures could be opened.

We also request at this time public meetings as well as workshops in the Dade County and Broward County area with all parties involved. These meetings and workshops must be held either in the evenings or weekend in order to get the proper representation. You can expect close to one thousand or more to attend these meetings.

This is a very important and controversial matter in South Florida at present Colonel Malson, please feel free to call on me at any time.

Sincerely,

Tom Cunard

Tom Cunard, President
Fishermen Against the Destruction of the Environment

cc: Wayne Nelson, CEO F.A.D.E.
Senator Bob Graham
Dexter Lehtinen, US Attorney
Mitchel Bridges, Everglades Holiday Park
The Florida Sportsman
The Miami Herald
The Fort Lauderdale News
The Palm Beach Post
Nathaniel Reed
Lewis Hornung, US Army Corps of Engineers
Jon Moulding, US Army Corps of Engineers
Bob Johnson, Everglades National Park
R. M. Brantley, Florida Game and Fresh Water Fish Commission
Frank Morello, Florida Game and Fresh Water Fish Commission
John Wodraska, South Florida Water Management
All South Florida Tackle Retailers
All South Florida Bass Fishing Clubs
All South Florida Salt Water Fishing Clubs
The Florida League of Anglers

4. An invitational workshop on the navigation issue was held in Broward County on the evening of October 16, 1990, and a public meeting was held in Dade County on the evening of October 22, 1990.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
Atlanta GA 30333

September 6, 1990

Mr. A.J. Salem
Chief, Planning Division
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

We have completed our review of the Draft Environmental Impact Statement (DEIS) and General Design Memorandum on Modified Water Deliveries to Everglades National Park. We are responding on behalf of the U.S. Public Health Service. Technical assistance for this review was provided by the Environmental Sanitation Program, Environmental Hazards and Health Effects Division, Centers for Disease Control.

Our review did not reveal significant adverse public health impacts as a result of implementing the planned project. Thank you for the opportunity to review and comment on this document. Please insure that we are included on your mailing list to receive a copy of the Final EIS, and future EIS's which may indicate potential public health impact and are developed under the National Environmental Policy Act (NEPA).

Sincerely yours,

Kenneth W. Holt, M.S.E.H.
Environmental Health Scientist
Center for Environmental Health
and Injury Control

University of Florida
Institute of Food and Agricultural Sciences
School of Forest Resources and Conservation
DEPARTMENT OF WILDLIFE AND RANGE SCIENCES
Telephone 904/392 5470
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Gainesville, Florida 32611 0303

7 September 1990

Draft EIS Comments, Everglades Deliveries
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Sir/Madam,

The following constitutes my comments on the Draft Ecological Impact Statement (DEIS) for the General Design Memorandum on Modified Water Deliveries to Everglades National Park.

My overall response to the DEIS is favorable. The GDM is a really concerted attempt to route and deliver water in a biologically sensible way in the Everglades. I am particularly supportive of the goal of designing flexibility into future water management options, since I believe firmly that our understanding of Everglades marsh processes is currently inadequate to commit to any rigidly administered system of deliveries.

However, I would like to note several important omissions which need to be addressed before the DEIS is submitted or approved.

1. The modelled effects of the GDM changes seem to stop within the freshwater marshes of Everglades National Park (ENP). There appears to have been no attempt to model effects (or even speculate on them) in the mangrove and estuary sections of ENP. I realize that Taylor Slough and Florida Bay are considered separate issues and are not treated in this DEIS. However, there remains a large section of coast from Cape Sable to Everglades City (at the minimum from Whitewater Bay to Rodgers River Bay) which are directly affected by flows from Shark Slough. The section from Whitewater Bay to Rodgers River Bay has historically contained the large colonies of wading birds (Lane River, Shark River, Broad River, East River, Rodgers River Bay, Duck Rock) that have in the past accounted for between 60 and 90% of all breeding birds in the Everglades ecosystem. Although the original requests for design modifications from the Department of the Interior sprang from concerns about alligator nests flooding and freshwater wading bird habitat drying up, this historical artifact should not dissuade the Corps from attempting to assess all downstream effects of the GDM changes within the Park's watershed.

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RESPONSES TO

Dr. Peter C. Frederick Letter of September 7, 1990

1. Plate B 1 of the GDM Appendix B shows the geographic extent of the Hydrologic Model. It was not appreciably extended into the mangrove/estuarine sections of the Park because those areas are tidally influenced. The interactions of tides, winds, and freshwater flow on hydropatterns in coastal areas cannot be simulated accurately with the present model configuration. It would be beyond the scope of this study to develop an estuarine model to extend into this area.

I am unable to tell from the analysis if this section of mangrove coast will recieve more or less water, and whether it will experience longer or shorter hydroperiod. Since the design modifications were originally requested, it has been noted that fisheries (both sport and commercial) have declined dramatically for fish living or spawning in these areas, and that the declines are related to freshwater flows. The lack of modelled effects is therefore striking.

(2)

I realize that the lack of water level recorders, coupled with the unpredictable influences of wind and tide in the mangrove section makes modelling water level difficult. I do not propose a detailed study is needed; only that the Corps make some statements concerning the expected (qualitative) effects of new water flow patterns on the mangrove sections, and particularly the mangrove/freshwater marsh interface.

2. Modelled effects include no estimates of drydown potential. Although drying rates are judged critical to the initiation of breeding, and breeding success of wading birds (Wood Storks are the original example),.there is no mention of this critical hydrological measure. It cannot be directly inferred from annual flows, hydroperiod, or median stage, and is therefore a clear omission. Drying rate has traditionally been measured as the mean rate of water level recession at any station, during the dry season only. Critical periods for stimulation of wading bird nesting are November through January, and January through April. These parameters should be explicitly modelled in order to assess the effect of the GDM changes on wading bird reproduction.

(3)

3. With the exception of the Snail Kite, monitoring of biological effects of the new water management scheme is not planned. I see this as an extremely important omission, serious enough to make the entire DEIS basically flawed. The reasons are as follows:

(4)

a. The GDM was explicity designed to give the maximum flexibility in future water management options, for the stated reason that future monitoring programs will probably demonstrate better ways of achieving our goals. Simply put, we are keeping our options open because think we may have to tinker with the system to get it to work right in all situations. Our ways of determining whether the system is working are expressed both in the achievment of physical design goals, and the achievment of biological benchmarks. Given that, the lack of a biological monitoring program as an explicit part of the GDM suggests that we are attempting to navigate a ship while wearing a blindfold. Not only will we not be able to tell if we ever reach our destination, we will not be able to make the minor (and inexpensive) corrections along the way. As in the past, we will only be able to recognize our mistakes when they are huge ones. A biological monitoring program is clearly a central piece of the GDM. This process was mentioned directly in each of the "White Paper" sections on wading birds, alligators, and estuarine and marsh fishes. The "White Paper" was used to formulate the GDM, and is deemed important enough to publish in the body of the EIS, and as such is distinguished in

2. The best indicator of relative freshwater flow into the west coast areas of the Park is the quantity of water passing into SRS across the Tamiami Trail (EIS Table 6). The MRD Operation would be expected to provide the most water flow of all the alternative operational strategies, and 25% more than under the Base Condition. However, the coastal mangrove areas are 25 to 30 miles from the Tamiami Trail, and as a result there would be no significant effects on hydroperiods. It would be speculative to attempt to address the significance of potential changes in salinity, especially since salinity in the mangrove marshes is more sensitive to winds and tides.

3. There was no direct presentation of drydown rates presented in the GDM. However, the USFWS derived this parameter from the Hydrologic Model output and used it in their wood stork HEP model (EIS Appendix D) to assess the effect of the GDM changes on wading bird reproduction. Also, see comment #17 in National Audubon Society's second letter dated January 4, 1991.

4. Ecological monitoring was discussed in DEIS paragraph 2.21. The Park has committed to a monitoring program as described in their letter of March 6, 1990 (Main Report Appendix A). This was inadvertently left out of the original report. The extension of this monitoring program north of Tamiami Trail will be the responsibility of the SFWMD as specified in the Local Cooperation Agreement that they must sign as the Local Sponsor of the project. Interagency coordination meetings on this subject will be scheduled in the near future. Funding for the Federal share of the monitoring is the responsibility of the Department of Interior.

importance from documents in the Appendices. It seems a glaring omission not to address these strong and consistent reccomendations.

b. By exclusion, it appears that Everglades National Park will have the only biological monitoring program that will be capable of assessing the effects of the GDM on an ecosystem level. Because of budgetary instability, Everglades National Park may or may not be able to monitor biological effects of the GDM in a meaningful way. We can assume that ENP will continue its long term monitoring of animal populations and ecological processes at some level. However, I am aware that the Park Service in general, and the South Florida Research Center in particular, have experienced fairly massive budget cuts in the last 8 years, and a number of monitoring programs have been cut entirely or in part. In the advent of future recessions, wars and Federal re-prioritizing, further cuts could easily render ENP's research program ineffective as the nearly sole monitoring arm of the effects of the GDM. It seems far better either to get the Park Service to commit to monitoring (as an explicit part of the EIS) or to design monitoring programs which will be funded through the GDM process and enacted by the Park Service or other research institutions.

c. No biological monitoring is planned for the Water Conservation Areas. While ENP is clearly the target of the GDM changes, the hydrological changes in Water Conservation Areas 2 and 3 are of even greater magnitude. This is an area of currently equal or greater biological abundance and diversity as ENP. The vast majority of wading birds in the Everglades currently nest in WCA 3, and the vast majority of the wintering birds (which are a large subset of the Southeastern United States population) use WCA 3 at some point during each winter. Further, with the drought mitigation plan for the Snail Kite in effect, WCA 3 will continue to be a very important dry season refuge for wading birds within south Florida, as it will remain wet long after ENP dries out in any year. Given this latter effect, we can expect that at least one large colony will form in a high proportion of years in the WCA 3 pool. Unlike ENP, no monitoring program is in place for the Water Conservation Areas. Lack of baseline comparison data is not a problem, however, since baseline data sets exist for game fishes, wading bird reproduction and wintering ecology, and marsh fish and invertebrate densities.

I see biological monitoring of animal populations in the WCA's as critical to the success of the GDM, and a necessary component of the EIS. If we end up trading serious degradation in the Water Conservation Areas for improvements in ENP, we will want to know that, even if the target for improvements is ENP. Again, the monitoring is critical to the evaluation process, and the key to adjusting the system towards desired goals.

The preceding paragraphs illustrate why biological monitoring is necessary to the success of the GDM. Obviously not all life forms can be monitored economically. However, marsh fish and invertebrates, wading birds, alligators, and vegetation, are all currently seen as important indicators of ecological change in the fresh and estuarine marsh systems. I suggest that monitoring programs include aspects of each of these, at a minimum. Monitoring need not be extremely expensive; wading bird populations and vegetative change can be monitored in large part from aerial surveys and satellite imagery. As above, biological changes in ENP can probably be monitored by ENP, but it is necessary to include a clear commitment from ENP stating their monitoring goals as part of the EIS. This does not add to the GDM budget at all. As for the Water Conservation Areas, an increase of only 3% of the total budget for the GDM would result in a large enough budget for five years worth of biological monitoring effort. While I do not suggest that this is necessarily a long enough period for monitoring, it is an example of how little more money is required for biological monitoring to be included in the GDM.

Sincerely,

Peter C. Frederick
Adjunct Assistant Professor

United States Department of Agriculture
Forest Service
Regional Office
1720 Peachtree Rd., NW
Atlanta, Ga. 30367

Reply to: 1950

Date: [illegible]

District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Dear Sir:

Reference the Draft Environmental Impact Statement for the Water Delivery System to the Everglades National Park, Florida.

We have no comments on the proposed project.

Thank you for the opportunity to review these environmental documents.

Sincerely,

JOHN E. ALCOCK
Regional Forester

FS 6200 28a (5/84)

September 10, 1990

Director of State Clearing House
Office for Planning and Budget
Executive Office of Governor
Tallahassee, Florida 32399-0001

Subject: "Goodbye L-67"

To Whom It May Concern:

I am a young woman in my early 20's living in South Dade. I grew up around the area of the Turnpike (West) and Tamiami Trail (South) watching Miami and South Dade grow right along with me, however I now feel that there is no control to all the growth.

Since I can remember, every time the word "Progress" or "New Development" appeared in the newspaper or referred to in the media, it simply meant "Failure" and "Destruction" to Florida's natural resources. Now, I ask you, can destroying vast amounts of precious land and waterways mean anything like Development? Does this mean developments for our trees, animals, and fish? Does it mean a better way of living for our voiceless Florida inhabitants?

I do, however, believe our "Progress" is turning into somewhat of a "Failure." Thanks to numerous amounts of senseless and costly construction projects turned in every year by architectural and engineering firms to be later paid by the taxpayers which I believe has caused failure to foresee this state's wildlife condition as it now stands and where it may be or not be years from now, or the polluted water system that we now are trying to "control." Why isn't a plan devised to clean up our polluted waters? Why can't these highly educated individuals, who obviously feel they know what's best for everyone, plan new projects or just finish old ones, for example: how to utilize salt water as an alternative for some fresh water uses, moreso than now; stop the dumping of waste into our waters by sewage companies; correct the mess at the Kissimmee River and other unfinished projects. The list is endless.

I simply do not see the absolute necessity or justice of having to destroy more of Florida's canals and natural environmental system, especially in the Everglades region, for a sheetflow to Shark River and better regulation of water all at the cost of 70 million dollars that may be put to better use elsewhere. If this continues the Everglades will eventually deteriorate and lose all of its wildlife, unless the land is re-filled and every highway crossing it be raised! Now there's a plan for the Engineers!

Goodbye L-67
September 10, 1990

I have studied the changes that the Army Corps of Engineers have suggested as well as the alternatives in the study. I feel that by simply plugging up the L-67 extension canal south of the Tamiami Trail, this would modify the S-334 structure on the east side of the L-29 canal and would add a pumping station in the same area (S-356) thus, leaving a minimal amount of change to occur in that area and minimal amount of disturbance to its natural surroundings. I am, however, totally against the changes as suggested in the original plan.

I sincerely hope that this project does not make another mark of man's attempts to change and destroy nature's constant struggle for survival, which we are constantly made aware of as we see our Cities and States "Progress" and "Develop."

Most Respectfully,

Nancy Alvarez del Real
Concerned Citizen &
Active Voter

4301 SW 61st Ave
Miami, FL 33155

cc: Army Corps of Engineers
Mayor Xavier Suarez

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, Florida 33702

September 17, 1990

Colonel Bruce A. Malson
District Engineer, Jacksonville District
Department of the Army, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Malson:

This addresses the Draft General Design Memorandum (GDM) and Draft Environmental Impact Statement for Modified Water Deliveries to Everglades National Park, Florida. The National Marine Fisheries Service supports the structural plan described on pages 58 through 65. This plan calls for removal of L-67-extended and its associated borrow canal and for construction of structures S-345 (A, B, and C), S-349 (A, B, and C), and S-355. The S-345 and S-355 structures would reroute water from Water Conservation Area 3A to the natural Everglades flow-way through what is now WCA-3B and Northeast Shark Slough (NESS). The S-349 structures, which are adjustable, would slow flows to the southern end of WCA-3A, thereby reducing the drainage of northern WCA-3B and enhancing flow from WCA-3A into WCA-3B.

These structures will provide the flexibility needed to develop and implement an optimal operating strategy for routing water to Everglades National Park. They are essential to the restoration of a more natural flow regime to the Park and its associated estuarine waters. The enlargement of S-333, as recommended by the U.S. Fish and Wildlife Service, would provide additional flexibility that might prove useful and should be added to the structural plan. (1)

We support the proposed process described on page 56 for developing an optimal operating schedule. We concur with the view that the operating schedule should be rainfall-based. Hydrologic modeling is essential to development of an optimal schedule. Models that have been designed or modified to approximate natural conditions that existed prior to man-made changes in the hydrologic system should be utilized. Such models would provide a perspective on natural spatial and temporal inflow patterns to the Park, expansion and contraction of water areas within wetlands, and flow to the estuaries. There are presently two existing models of this type, one developed by MacVicar and Johnson (South Florida Water Management District and Everglades National Park) and the one developed by Carl Walters at the University of Florida.

RESPONSES TO

National Marine Fisheries Service/NOAA Letter of September 17, 1990

1. An enlarged S 333 would not be effective in offsetting the need for the S-355's or in providing cost-effective flexibility. Its proximity to S-12D and the removal of L 67ext. would combine to result in a rise in tailwater elevation at S 333 during times of high discharge, resulting in a decreased discharge capability that would effectively negate much of the desired results.

From our perspective, the modified raindriven plan is an acceptable interim plan. It could be improved substantially by allowing the adjustable S-349 structures in L-67W to close during high volume flow periods and possibly through much of the wet season. Using these structures to slow canal flow to the downstream end of WCA-3A would reduce the need for regulatory releases through the S-12 structures and would increase the proportion of total flow that is channeled to the natural Everglades flow-way through WCA-3B and Northeast Shark Slough. We urge that the first in-house modeling activity conducted by the Corps simulate the effects of opening and closing these structures in response to rainfall conditions. Even temporary implementation of an improved modified raindriven plan, pending agency agreement on another plan, would be advantageous to the Everglades restoration effort.

(2)

The basic raindriven plan also is acceptable as an interim plan but we believe it also could be improved. Although the raindriven schedule is commendable in concept, the actual algorithm may be faulty because it is based on the relationship between rainfall and surface flow to the Park during the 1950's, after the upstream hydrologic system had already been altered greatly. The release volumes relative to rainfall prescribed by the current algorithm may be insufficient to restore natural functioning of the Park's aquatic systems, including Florida Bay. Deficiencies during low-rainfall periods may be more important than those during high-flow periods. Models that approximate natural hydrologic conditions could be useful in refining the raindriven algorithm to better simulate natural timing, flow volumes, and wetland flooding and drying patterns.

(3)

The GDM provides no mechanism for insuring that the release volumes prescribed by a raindriven schedule will be met in future years as agricultural and urban consumption grows and storage for wet season surpluses decline. By storage sites, we mean the wetlands, peat deposits, and limestone formations that accumulate water when it is abundant and then slowly release it like the base flow of a river. Such dynamic storage reduces the impact of dry seasons and dry years. Legal assurance of the Park's water rights should be an integral component of the future raindriven operating plan for water releases to Everglades National Park.

(4)

Technical questions regarding these comments should be addressed to Dr. Joan Browder at (305) 361-4270 or Mr. Mark Thompson at (904) 234-5061.

Sincerely yours,

David D. Rockley

for Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

2. Additional modeling and coordination will be conducted to develop an improved system operating strategy. All appropriate alternatives will be considered, including various operating criteria for the S-349 structures.

3. Usefulness of suggested models will be investigated.

4. Legal assurance of the Park's water rights are provided in the Congressional authorizations for minimum water delivery to the Park for the Experimental Program and for the GDM. It is not appropriate for an operating plan to provide such assurances.

TO: DEPARTMENT OF THE ARMY 9-23-90
Jacksonville District
CORPS OF ENGINEERS
RE: CONSTRUCTION PROJECT L-67 CANAL

GENTLEMEN:

I am writing to comment upon the proposed project on portions of the L-67A canal in Dade County. I have supported earlier the Kissimmee River Restoration Project, and wrote to Governor Martinez regarding this. I believe it is a necessary project to reclaim this and other areas here in South Florida to maintain habitat and to provide adequate water flow to the Glades. I feel it is important to point out that your corps was involved in prior decades in projects that have led us to the present desperate situation of trying to save the Everglades, however.

I am both an avid fisherman and waterfowler who has used the still viable, but threatened areas such as Lake Okeechobee, Sawgrass in Broward County, and the L-67 Wildlife Management Area. The latter I am especially concerned with since this is close to home. We have already a great problem with mercury contamination in the L-67 Area and I cannot consume fish from these waters. What impact will the damming and diverting of the [illegible] have on the land east to be [illegible] [illegible] area? I am in favor of [illegible] water flow ("natural") to the Glades south but at

(1)

F-14

RESPONSES TO

Mr. Raul A. Garcia

Letter of September 23, 1990

1. See response to comment #3 in F.A.D.E. letter of September 4, 1990.

what price? Will this impact the aquifer
underlying the proposed filtering area? Will
this only contaminate a greater area?
(2) Will this exacerbate eutrophication of the
area east and west of L-67A?
I surveyed the land west of L-67A (on 9-22-90)
in the management area. The water level was
approximately 2 feet which is higher than it
has been in a long time due to the
much-needed rains of this summer. Will the
(3) diverting of water east lower the levels west
of the canal? If so, this will doom this
area for fishermen and hunters like myself.
The shallow area is prime habitat for fish
birds, and feeding areas for migratory waterfowl.
As a hunter I am also a conservationist and am
pledged and contribute money toward the goals of
maintaining WMA's and habitat for the preservation
and enjoyment of future generations. I am
afraid that by lowering water levels of the area
west that is, North of Tamiami Trail, this will
mean the end of this habitat. We cannot
tolerate any development in these sensitive
areas!! What I object to is the continuous
(4) trend to cutting off public land from the
public and access [illegible] on L-67A that
[illegible]
(5) [illegible] these [illegible]

2. Project features will have no adverse impacts on the aquifer.

3. Water stages in the area west of the proposed structures would be higher with the project.

4. See response to comment #1 in F.A.D.E. letter of September 4, 1990.

5. The project purpose is to benefit the natural resources of the Park which have been severely degraded as a result of the unnatural impounding and release of water from the WCA's east and west of L-67A. There would be no adverse effects from a return to a more natural water flow through the WCA's.

be most happy to hear an explanation. From my limited knowledge from the newspaper article outlining the project I see the possibility of contaminating a largely pristine area (east of L-67A) and endangering the water supply. The second fear is the possible death to the Management Area west of L-67A and north of Tamiami Trail by lowering the water levels. The bottom line is that I support mandatory water restrictions because we are still in a drought period on deficit in water, the politicians here are pushed by developers to change limits, thus we are losing prime habitat and hunting areas. And I cannot support a project that aims to increase the water flow to the south Glades if it jeopardizes adjacent areas and on balance loses more than it hopes to gain. Please illuminate me on this matter if at all possible. I hope God and human Comrans lights your way so that you do best for the land and the people. If we cannot love the land we will lose everything. I wonder if my grandchildren will ever be able to fish and see a flock of wild ducks rowing the marshes at sunup? I thank you for your attention.

Raul A Garcia
[illegible]
[illegible] 33155

6. The general goal of the project is to restore natural hydrologic conditions. Consequently, during droughts, very little if any water would be delivered to the Park since overland flow would have been negligible in the "natural" system. Adequate supplies of water during the full range of conditions must be assured.

NATIONAL AUDUBON SOCIETY

RESEARCH DEPARTMENT • 115 INDIAN MOUND TRAIL • TAVERNIER, FL 33070 • (305) 852-5092

24 September 1990

Dr. Jonathan D. Moulding
U.S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232

Dear John,

We have just completed a review of the Environmental Impact Section of the General Design Memorandum for Modified Water Deliveries to Everglades National Park. We commend you and the U.S. Army Corps of Engineers (ACE) for putting together an impressive document that summarizes so thoroughly the restoration effort and the problems it faces. We have some comments that we would like to make on this draft and on the restoration effort. These cover eight general points.

1. We support the early construction of the structural changes described for the full project.
2. We consider the ability to fine tune system management to meet overall objectives very important. We are not completely satisfied with any of the proposed management strategies and we doubt that the optimum strategy will be devised and recognized until after the system has been in place.
3. We believe that the successful restoration of the Everglades will require close integration of management strategies throughout the system: in the C-111 basin, in the Everglades Agricultural Area, etc.
4. We believe that management of the Everglades should follow ecosystem management principles, rather than single-species management.
5. We recognize the Everglades' need for an assured water supply and support efforts to reserve an adequate supply.
6. We see a critical need for a detailed and verified whole-watershed water budget including the Everglades, Lake Okeechobee, and the Kissimmee Valley.
7. We see in particular a need to coordinate water management between the Everglades, as described here, and Big Cypress Preserve.
8. We feel that the issue of operational strategies during the period of construction is not adequately addressed.

These comments will be addressed more fully below.

In general we support the recommendations of the ACE that the full structural changes described in the GDM be constructed immediately. This will provide flexibility in recreating sheet flow through Water Conservation Areas 3A and 3B, into Northeast Shark Slough, and into Everglades National Park. We agree that operation of these structures will need to be fine tuned over the next decade until a management system that best simulates the wanted conditions is attained.

AMERICANS COMMITTED TO CONSERVATION

We agree that the management of these structures will need to be fine tuned over the next decade to actually reach the restoration goal. This requires that a mechanism be in place at the time of completion of the structures that will allow periodic evaluation and adjustment of the management plan. Monitoring of critical variables and additional simulation modeling of the system will need to be done over the next few years to provide the key data for fine tuning the system. We hope that the National Audubon Society can play a constructive role in the interative process of developing the optimal management strategy. (1)

We strongly believe that an ecosystem-wide approach to the restoration of the Everglades is the best way to improve conditions for the greatest number of plant and animal species. All the Endangered and Threatened species that breed within the system evolved in the system under its wet-dry cycle and with the multi-year pattern of wet years and dry years. Restoring a more natural pattern of water flow that simulates better the historical volume of water, timing of flow, and distribution of flow through the Everglades will crease conditions that would restore historical hydroperiods. The more historical hydroperiods should allow the vegetational-periphyton communities to develop, fish and invertebrate biomass to increase, and therefore wading birds, Snail Kite, and Alligator populations to increase.

The fine tuning of the management plan will require careful monitoring of key indicator species and groups in the system and additional investigations of water budgets and water flow models. Wading birds as a group might represent the best indicators of the health of the system. They are near the end of food chains and therefore should respond to changes in the system. They are relatively easy to monitor. The different species within the group are likely to respond differently to some changes in the system providing important feed-back on the success of the restoration effort. Monitoring of foraging distribution, breeding distribution, and some measure of breeding intensity and success could prove important. Monitoring Alligator nesting during the wet season may provide important information on the success of the restoration of wet season water flows and their timing. Monitoring of periphyton communities, plant community changes, and fish populations will also be important. Dr. Durbin Tabb's work showed that algal communities should change in response to improved hydroperiods and water depths. These communities will affect soil formation, primary productivity of the area and therefore secondary productivity. It therefore seems critical that some monitor-research program be developed to examine these groups.

We are opposed to a single species approach to managing and restoring the Everglades. This approach would lead in the long term to the continued degradation of the system with probably eventual loss of more species. Obviously consideration must be given to Endangered and Threatened Species in the formulation of a restoration plan. It is critical to maintain these species as the greater area is restored. In the long run the ecosystem restoration is likely to benefit these species more than trying to manage a single area for just one species.

Water supply to the Everglades is a critical variable that could limit the success of this restoration effort. It is unknown how much of the Everglades annual water budget is allowed to flow through the system, how much is used by agriculture, used by municipalities, and how much is diverted out of the system in the name of flood control. Water flow simulation modeling done by Dr. Carl Walters of the University of British Columbia suggests that the volume of water that historically flowed through Shark Slough and into the estuaries of the west coast was greater than the volume currently available. (2)

RESPONSES TO

National Audubon Society **Letter of September 24, 1990**

1. See response to comment #4 in Dr. Frederick's letter (page F-8). Your input on the value of this and other methodologies will be sought during the upcoming coordination on the ecological monitoring program.

2. The formula for the rainfall-based component of water deliveries to the Park under the MRD and BRD Operations includes assumptions on volumes of flow through the Everglades that would have occurred historically under similar rainfall regimes. The delivery volume calculated by the formula would be a guaranteed amount under the authorizing legislation. The regulatory release component of delivery is made only under flood conditions in WCA 3A, and is, therefore, considered excess water in the system not subject to guarantee. Any future action that reduces the amount of surplus regional water would have the potential to reduce the amount of regulatory releases to the Park. Allocation of adequate water for the Park under the recommended operational concepts must be based on the rainfall component; changes in such allocation would be accomplished by changes in the formula associated with the assumptions of historical flow, or perhaps ultimately through operating experience over many years. Any questions on adequacy of delivery volumes in the recommended plan would need to be addressed during the planned review of operating strategies.

The growing human population of south Florida is continuing to demand more fresh water. Increased diversion of water from the Everglades could jeopardize this restoration plan. It is therefore critical that the ACE encourage and participate in studies that will lead to a better understanding of the water budget of south Florida and when the Corps issues or reviews permits that could influence water volume in the Everglades they rule in a way that will insure adequate water for the Everglades. We urge that the enabling legislation for this project also include a mandate to allocate adequate water to the Everglades to allow it to function as a healthy, natural marsh, similar in process and biota to the historic Everglades.

Productivity of estuarine systems is positively correlated with the volume of fresh water that enters them. The interface between the freshwater marshes and the estuaries was the historical nesting and feeding areas for the Endangered Wood Stork and wading birds. The volume of water flowing into these areas will affect productivity, hydroperiods and availability of prey and therefore the probability of restoring these large and important nesting areas. We are concerned that necessary volume of water to achieve this restoration will not be allowed to flow south under some of the proposed management regimes.

Dr. Walters' modeling shows that during many years and especially high rainfall years, water that would have flowed through the marshes that are now the Everglades Agricultural Area (EAA) become an important component of downstream flow all the way to the estuaries. This flow, however, may take as much as a year to reach the estuaries. This water is unquestionably critical to the restoration effort. The canal system through the WCAs greatly increases the rate of flow through the WCAs and to ENP. We feel it is critical to increase sheet flow through the WCA to decrease this pulsing effect. We support the closing of the proposed S-349 structures in the L-67 canal so as to decrease the flow rate past WCA 3A. The cleaning of water that leaves the EAA is also critical for the restoration effort. The ACE should strongly support efforts to clean this water and demand that progress be made immediately. (3)

The operation of the South Dade Conveyance System may also influence the flow of water south through Shark Slough. Some evidence suggests that current management of this system is increasing flows south through L-31 and into the C-111 basin. These flows are greater than would have occurred if this area was still natural. In developing the flood protection plans for the "8 square mile Area" in the East Everglades it is critical that operation does not adversely impact other areas. (4)

The operation of the S-343s and S-344 structures along the L-28 levee are not discussed in any part of the GDM. Will feel strongly that this is a major oversight that should be rectified. Based on topography, water flowed at high stages from what is now WCA 3A into the Big Cypress area and south through the sloughs in the loop road area west of 40-mile bend. These sloughs are extremely important foraging areas for birds from the large breeding colony at Rodgers River Bay. Management of flows through these structures should be included in any overall management design for the lower end of WCA 3A and WCA 3B. We urge that the current management of these structure be carefully evaluated and that flows through them be included in the overall water management scheme for WCA 3A. Dr. James Kushlan's letter in the GDM document also suggests increased water flow into these areas. (5)

We are concerned that the GDM document does not adequately address the operational strategies to be used during construction of the project. We feel that the potential for inadvertent (6)

3. The Corps supports the water quality remedies forwarded by the Federal Government in U.S. vs SFWMD.

4. The existing canal flows south through the C-111 Basin are artificially high as a necessary result of the Experimental Water Delivery Program. The physical capacity of the existing system is not adequate to fully or even partially restore flows to NESRS without impacting adjacent development. To avoid such impacts during the testing program, large releases down C-111 have been necessary. Flows will return to more normal levels when the GDM-recommended plan is put into effect.

5. As can be found on Figure 11 of the Draft GDM, the operation of WCA No. 3A included the S-343's and S-344 structures.

6. The Corps will design and schedule construction activities for each project feature that would minimize environmental disruption at each site. These considerations will be addressed in the next phases of engineering and design (Feature Design Memoranda). The last construction feature would be the degradation of L-67 Ext. No part of the new operational plan is expected to begin before this is completed. The L-67A Canal must be functionally maintained during construction so that it would be usable for its authorized purpose of water supply conveyance. The L-67C borrow canal serves no hydraulic purpose in the system. However, if practical, it would be kept open during construction for fishing boat access.

abuse of the habitat is great and so we urge that this be addressed more fully. In particular, is the south end of WCA 3A at risk of drying out during construction of the S-349 structures? What will be the effects of increased water in northeast Shark River Slough before removal of the L-67 extension? Will the operation of the S-345 structures and the S-355 structures be phased in simultaneously, or offset? Will the L-67c borrow canal be blocked before the S-345 structures are functional, and what effect will that have?

We reiterate that, overall, the National Audubon Society approves of this project and sees it as a major positive step in the restoration of the Everglades. We hope that the several points we bring up can be addressed in the final GDM document and, as appropriate, in the enabling legislation.

Sincerely,

G. Thomas Bancroft, Ph.D.
Research Biologist

Wayne Hoffman, Ph.D.
Research Biologist

GTB/WH:np

cc: Robert Chandler, ENP
John Ogden, ENP
Alexander Sprunt IV, NAS
Larry Thompson, NAS

1106 San Villa Drive
Vero Beach, Florida 32960
October 17, 1990

Colonel Bruce A. Malson
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Reference: Modified Water Deliveries to Everglades National Park

Dear Colonel Malson:

I've reviewed the draft General Design Memorandum and Environmental Impact Statement regarding the referenced project, and offer the following comments.

GENERAL COMMENTS

There certainly is need for improving hydrologic conditions in Everglades National Park; in fact, you should be planning to meet water needs of the entire remaining Everglades. There is a real question about the adequacy of water supplies. All of the water delivery scenarios for the Modified Water Deliveries project are based on demands and supplies for the base year, 1990. Given the rate of growth of south Florida, and the profligate use of water, a rationale assuming that water supplies and demands will not change in even the immediate future appears inaccurate.

The delivery alternatives reviewed in these documents should have been tested under circumstances including: greater supplies of water for the Everglades (if water consumption by other users were restricted, or increased storage and conveyance were available); reduced supplies of water for the Everglades (reduction could occur under greater on-site retention in the Everglades Agricultural Area, changing regulation schedules in the other WCAs, or raising Lake Okeechobee's schedule). The alternative delivery scenarios would have produced far different hydrologic conditions in the Park in response to this range of supplies.

About half of the water entering the Park is not even called for by the delivery formulas. This half of the supply may be claimed by other users (see EIS-37, 4.52), defeating or reversing project benefits. Therefore, the water needs of the Park, A.R.M. Loxahatchee National Wildlife Refuge, and the other Water Conservation Areas (WCAs), should be identified. Adequate water should be allocated to insure that the project benefits can be realized, and the balance of the Everglades will remain viable. This balancing of water allocations should be more fully evaluated in the General Design Memorandum (GDM) and the Environmental Impact Statement (EIS).

There appear to be a great many inconsistencies between statements in the EIS and the body of the GDM. Each of these sections has sets of data tables and appendices; the narrative portion of the EIS conforms better

with the supporting data than does the GDM. Many of the hypothetical project environmental benefits described in the GDM are not supported by data presented in that document. These discrepancies should be rectified in the final documents.

The GDM frequently dwells on the proscription against selecting one of the delivery alternatives, the Basic Raindriven (BRD) plan, because of the finding of its adverse effects on the endangered snail kite. The implication is that one resource, the endangered species, is pitted against ecological restoration. However, the ecological objectives can be met as
(1) well or better with another of the alternatives, the Modified Raindriven (MRD) delivery plan. The relative performance of each alternative is thoroughly documented in the EIS tables, the appended Fish and Wildlife Coordination Act (FWCA) report, and its appendices. Therefore, the GDM narratives should be corrected to more fairly describe the relative performance of each alternative, in accordance with the documented analyses.

SPECIFIC COMMENTS ON THE GDM

p. 24 & 25. The objectives of the project have apparently been revised from those in the General Plan and the Park Expansion Act. That Act focusses on restoration of hydrologic conditions within the Park, including the expanded boundary to the east. However, the draft GDM chooses to interpret this as justification to seek to "restore the hydrology" of the huge WCAs to the north of the Park. The WCAs are under management of the Florida Game and Fresh Water Fish Commission, a party to the Fish and Wildlife Coordination Act, which has repeatedly expressed opposition to
(2) altering hydrology of WCA3B, in particular, until water quality concerns have been satisfied. Alteration of flows in the WCAs is not essential to restoring flows in the Park; alternative routings are possible which avoid impacting WCA3B while meeting the project objectives. Moreover, the proposed hydrologic "restoration" of the WCAs, now put forward as a project objective, is in conflict with needs of federally listed endangered species. Therefore, the GDM should plan to meet the original mandate for restoring the hydrology of the Park, and delete criticism of scenarios which do not "restore" the Water Conservation Areas.

(3) p. 24; 3. I was not aware that the Corps was restoring WCA3B "on an experimental basis"? Is this an ongoing operation, or a misstatement?

p. 26; a. This discussion of the timing of water deliveries should be revised. Flows under the minimum delivery schedule were, in fact, related to rainfall (leading to regulatory releases, which still would occur under
(4) the rainfall delivery plans). Also, the "guaranteed deliveries" in the dry season somewhat mimicked natural flows reaching the Park from the northern Everglades. The current rainfall formula apparently exaggerates dry season cut backs by underestimating these "lag" flows from the north. Abandonment of the minimum delivery will limit "natural operations", when rainfall formula expectations are not met in dry years.

(5) p. 26; b. The GDM should note that the deepest part of Shark River Slough was just to the east of the project area, south of WCA2 and east of WCA3.

RESPONSES TO

Dr. Arnold Banner — Letter of October 17, 1990

1. The threat to the snail kite was the only reason listed by the U. S. Fish and Wildlife Service for their opposition to the BRD.

2. Section 104 of the Everglades National Park Protection and Expansion Act of 1989 states the following: "the Secretary of the Army...is authorized and directed to construct modification to the Central and Southern Florida Project to improve water deliveries into the park, to the extent practicable". Restoration of WCA No. 3B is part of the authorized modifications to the C&SF Project. This area is now isolated by a surrounding levee system, with rainfall accounting for most of its water supply. The restoration of WCA No. 3B to the everglades hydrologic system would plays an important role for achieving the goal of hydrologic restoration of ENP. Restoration of WCA No. 3B was requested in the seven point plan proposed by ENP.

3. The ongoing experimental program does not include WCA No. 3B. Text in the GDM has been revised to explain when this test took place. The experimental use of WCA No. 3B is described in paragraph 4B.b.(1) entitled "Original RD Operational Test".

4. The Modified Minimum Delivery schedule, although it was based on average annual rainfall, never really simulated nature. The minimum deliveries were set by law and became an average annual cycle for the Park. This average annual condition does not happen in nature, and does not provide for periods of "bonanza and scarcity" of water. The rainfall component more closely simulates nature by following the dry and wet timing that nature produces. Under natural conditions, no flow would have occurred during drought conditions. Unlike the minimum delivery schedule which continues flows regardless of the severity of the drought, the rain-driven formula will discontinue flows during drought. Some have contended that the rain-driven formula discontinues flows too soon. Unfortunately, there are not adequate data available to verify this. However, if future testing and/or studies indicate the need for a revision of the formula, the physical water management system provided by this project will enable an appropriate operational adjustment.

5. Although the original flow path can not be restored as it once existed, the objective of the project is to restore the ecosystem over a wide area to compensate for alterations done by man.

Therefore, the original flow path cannot be fully restored. The deepest part of the slough provided long hydroperiod conditions which now only occur in the southeast corner of WCA3A. This habitat type would be greatly reduced under the raindriven scenarios considered to date. The GDM should observe this as a drawback, rather than a restoration benefit.

A less costly way of delivering water to Northeast Shark River Slough (NESRS) would be to enlarge Structure 333, and pass flows down L-29 canal, then into the Slough. This also would avoid conflicts over management and water quality concerns in WCA3B. Note that S-333 is expected to deliver most of the flows under either raindriven plan examined; only 24 to 36 percent of the flows sent to NESRS would go through WCA3B (derived from Table 7). (6)

p. 26; c. I question the statement that current water volumes are more than sufficient to restore natural hydrology. They seem to fall far short of water needs projected by the Park for their "natural" scenario, or to meet desired stages in NESRS (see appendix to the FWCA Report and EIS-27). It may be that control of water stages necessary to prevent flooding to the east, or reduced ability to retain water to the north have caused the Park's deliveries to peak and fall more rapidly than occurred historically. Thus, the same volumes delivered would not produce the hydroperiod characteristics apparently being sought. (7)

p. 36; c. This sounds as if a goal of "more frequent dry outs" is held for WCA3A. This objective is not justified by legislation or by need for meeting other project objectives. Certainly more frequent drying of Critical Habitat of the snail kite is not an appropriate goal for any agency bound by the Endangered Species Act. (8)

p. 37; d. The GDM should recognize shortcomings of the current array of delivery alternatives. According to the Park's analysis, the BRD plan improves conditions but does not keep the core of Shark Slough flooded throughout most years. This delivery plan and the MRD could probably be improved by supplying greater volumes of water, and prolonging wet season/early dry season releases, to mimic historic flows arriving from the northern Everglades. (9)

p. 40; 52. The Summary is in error. While only the BRD plan jeopardizes the snail kite, the MRD plan does cause adverse effects; it is the MMD plan which does not. Also, the MMD plan improves airboat access more than the MRD. The effects on water supply are actually beneficial from the raindriven plans. Both use more water in wet years, when supplies are not of concern, and use less water than the Base in drought years (see Biological Opinion, appended to the Coordination Act Report). (10)

p. 41. Not all alternatives are in compliance with applicable statutes. Only the Base, MRD and MMD plan are in compliance with the Endangered Species Act. The others either were not reviewed or found to cause jeopardy to listed species. (11)

p. 42; Table. It should not be implied that the lack of need for monitoring under the FT, RD, and BRD plans is a positive aspect. (12)

6. Enlarging S-333 to deliver flows to NESRS would not allow deliveries throughout the full range required. Due to their proximity, the S-12's tailwater would considerably affect the delivery capacity of S-333 to NESRS. The S-355's would be more effective since they would include WCA No. 3B.

7. The GDM has been revised to delete the sentence in question.

8. The MRD provides for additional flows to WCA No. 3A to protect snail kite habitat. Although, as expected during severe droughts water stages in the area would fall below desirable levels despite any attempts to bring additional water from Lake Okeechobee. These conditions would occur naturally under all alternatives including the base condition. When water becomes scarce all competing water users would have to share adversity. Water allocation, when Lake Okeechobee falls within the "Warning Zone", would be conducted under the Water Shortage guidelines of the South Florida Water Management District.

9. The GDM proposes the structural features that will allow the restoration of the Everglades. Operations of the structures will be developed through an iterative testing process to maximize project benefits. This recognizes that no one rain-driven delivery scheme is better than the other, but that time and testing would produce the best water management strategy.

10. The GDM has been revised to reflect the comment. However, there is no reason to expect airboat access with the MMD to show an improvement over Base.

11. Referenced paragraph has been corrected. However, referenced table in the GDM shows the BRD would not comply with the Endangered Species Act.

12. The table has been revised to reflect the comment.

Monitoring is not required only because these plans either never were reviewed under the ESA or were rejected based on effects on snail kites.

p. 49. "Volume". The GDM should not imply that water volumes represent "natural" supplies to the Park. Diversions for flood control and consumption may significantly affect available supplies. Hydroperiods under the alternatives examined do not at all look like those estimated for the historic condition by T. McVickar of the South Florida Water Management District (see Park's report, appendix to FWCA report). (13)

p. 49; 61a. The GDM implies that benefits accrue to the Park by filtration of pollutants in the Water Conservation Areas. This view should be tempered by noting that water quality in WCA3 A and B would be degraded in proportion. None of the Everglades should be subjected to unnatural levels of nutrients. (14)

p. 51; e. Birds do not benefit from "greater flexibility". Benefit will accrue only if management actions are taken in the bird's favor. Modeling by the Park and Service does not show overall benefit to wading birds from the raindriven alternatives examined (see data or EIS). (15)

(16) p. 51; f. Alligator habitat should be relocated eastward, with minor expansion. The Park's analysis shows that nest flooding increases under the raindriven alternatives examined, but that population levels could increase somewhat.

p. 53; First increment. The GDM should delete statements explaining that the first increment would not "restore WCA3B". Neither the legislation nor the planning parameters that went into this GDM support restoration of WCA3B as a legitimate goal. Further, there is no evidence that WCA3B would ecologically benefit from the alternatives investigated, or that it requires adjustment. The responsible agency, Florida Game and Fresh Water Fish Commission, asserts that this area is ecologically valuable in its current condition (see their letter appended to the FWCA report). (17)

The GDM does not explain what is meant by "continued regional loss of seasonal habitat diversity". The Base condition would not necessarily lead to loss of habitat diversity. On the other hand, "restoring" WCA3A has potential for reducing regional diversity by eliminating remnant long hydroperiod habitats.

Park studies show that the raindriven alternatives would not be an improvement over continuation of the Base in regard to wading bird and alligator nesting. The GDM should present a more even-handed appraisal. (18)

p. 54; Second increment. The paragraph understates the benefits from this increment. Alligator nest flooding was lower for the modified minimum alternative than for subsequent "increments". Wading bird nesting success was highest under this increment, then decreased. WCA3B is now fully available for use by wading birds; no data are presented showing that it's productivity is low. (19)

(20) p. 54; Third increment. The GDM reaches conclusions about ecological benefits based on full use of the various structures, which are not

altered the Everglades. The project is intended to deliver the Everglades following the cyclical weather conditions in the area.

14. Currently water pumped from the EAA and percolated rainfall is allowed to flow into the Everglades. Diversions through the marsh of WCA's 3A and 3B will allow the overall quality of water to improve. Under the MRD plan, southerly flow to the S-12's is predominantly sheet flow in the wet season and canal flow in the dry season. During the wet season, water quality would be higher due to the assimilative capacity of the marsh vegetation, and because the concentration of nutrients would be lower. During dry periods, higher nutrient canal water at the S-12's will not be delivered until rain events had begun. This not the case with the modified minimum delivery schedule where canal flows would be delivered during the dry season. The SWIM plan will address water quality in the EAA area in conjunction with the conditions in the settlement agreement of the court case "US vs SFWMD and DER".

15. The "greater flexibility" in the sentence refers to the water management options available with the project in place. In developing the final operating criteria for the project structures, wading birds will be given equal consideration along with the other factors which will make up the operating criteria. Wildlife models as presently constructed do not show overall benefits to wading birds accruing from the recommended MRD Operation. They do show a modest but statistically insignificant improvement resulting from the MRD Operation which would not be sufficient by itself (or in combination with other wildlife model results) to justify selection of that operation over the very broad-based support for the rain-driven operations. The "flexibility sentence" will be reworded to make its meaning clearer.

16. The paragraph under comment was taken verbatim from the alligator writeup in the White Paper (EIS Appendix C). As such it stands on its own. However, it is thought that the alligator population south of the Trail is confined to less suitable habitat than would ultimately be restored in NESRS. It is expected, therefore, that the population center would eventually shift eastward, as the comment suggests.

17. The "Environmental Incremental Analysis" is presented as a tool for analyzing environmental benefits the project would achieve as features were completed. WCA 3B has been virtually isolated from the everglades ecosystem with the majority of its water coming from rainfall, seepage, and flooding. Part of restoring the natural hydrological conditions to the Park involves reconnecting WCA 3B to the Park to allow the everglades to function as a unit. The statement "continued regional loss of seasonal habitat diversity" refers to the integration of WCA 3B to the Everglades flow way. Although WCA 3B is integrated into the Park during this first increment, water would still be shallow and fluctuate little causing the continued loss of seasonal habitat diversity. As much as half of the historic Everglades has been lost due to development. Most of the remaining undeveloped Everglades is within the WCA's. Restoration of natural hydrologic conditions within the political boundaries of the Park cannot fully "enhance and restore the ecological values" of the Park which is the purpose of the authority provided by PL 101-229. The Law authorizes the Corps to "construct modifications to the C&SF Project to improve water deliveries into the Park". Furthermore the Law states that the project will be "justified by the environmental benefits to be derived by the Everglades ecosystem in general and by the Park in particular". Restoration of WCA 3B as a functioning component of the Everglades system is an important component of the project that is supported by the legislation.

Monitoring is not required only because these plans either never were reviewed under the ESA or were rejected based on effects on snail kites.

p. 49, "Volume". The GDM should not imply that water volumes represent "natural" supplies to the Park. Diversions for flood control and consumption may significantly affect available supplies. Hydroperiods under the alternatives examined do not at all look like those estimated for the historic condition by T. McVickar of the South Florida Water Management District (see Park's report, appendix to FWCA report). (13)

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of the full structural plan as essential to restoration of the Shark River Slough basin". The GDM is prepared for higher authority and presents Corps of Engineers conclusions. Conclusions reached by the Park are presented in Appendix D of the EIS.

19. The second increment presents the point that restoration is beginning but has not fully taken place (the third increment). The increments are to describe the ecological benefits of the recommended project features as they are brought on-line. The alligator nest flooding for the modified minimum alternative is not an issue in this part of the GDM. WCA No. 3B bird productivity is low because the marsh ecosystem has not been fully restored under this second increment.

20. Currently the stages in WCA No. 3B fluctuate based on rainfall only. By now adding the surface water component, stages in WCA No. 3B will be closer to those that once occurred. The surface water component into WCA No. 3B will also ensure that the hydroperiods are longer, thus providing better foraging for wading birds.

supported by the data presented. Water levels in WCA3B fluctuate annually already. Indeed, biologists hold it to be perhaps the most natural component of today's Everglades (see EIS findings). It is currently supplied by rainfall, and the Florida Game and Fresh Water Fish Commission has expressed concern that water quality would be degraded under this increment. Hydrological conditions would not change dramatically in WCA3B under any alternative (see EIS appendices, FWCA and Park data), and there is no support for this dramatic forecast of impressive ecological benefits.

Diversion of water through WCA3B does not appear to form the primary pathway for rainfall deliveries to the Park. Table 7 shows that only about 14 to 21 percent of overall flows would pass through WCA3B. None of the alternatives are seen to "fully restore" hydrology of the Slough, based on Park analyses. I fear that the GDM's exaggerations will deflect attention from the real need for an assured water supply for ecological requirements of all of the Everglades.

p. 56; par. 1. While the proposed structural features would allow an "array of operating criteria", the GDM should note that these will be circumscribed by certain limitations. For example, operation according to the Basic Raindriven plan was supposedly "abandoned" because it was found to jeopardize the continued existence of the endangered snail kite. Timing and volume objectives can only be accomplished if there is sufficient water available, at the necessary times, for use with the new structures. While iterative processes should lead to selection of an optimum delivery plan, they cannot be said to "accomplish" the acquisition of necessary water supplies. The latter will require administrative action and some compromise between competing users. Again, the section should be rewritten to give a more realistic appraisal of benefits and limitations of the project. (21)

p. 59; par. 2. The description of the operation of the S-349 structures is not that modeled for the MRD plan; the BRD plan (which uses the S-349 structures) was found to jeopardize the endangered snail kite. The BRD was supposedly abandoned, based on this finding. (22)

p. 79; 90. Phase 1 appears to be largely the same as the MMD plan. Elsewhere this document acknowledges that a significant portion of the hydrologic objectives can be achieved with this plan. Moreover, it was the only plan benefitting both affected endangered species. (23)

I see no evidence that WCA3B needs to be altered to make it "an important nesting site for wading birds". Park analyses show that the raindriven plans, which supposedly act to "restore WCA3B", reduce nesting success in the project area.

(24) Figure 2. The graphic depiction of the 4 parts of the project area is grossly distorted. WCA3B is much smaller than WCA3A. Also, the objective of changing conditions in WCA3B is not justified by legislative directive or other planning goals.

(25) Table 9. Gauge 3-29 is in WCA3B, not WCA3A. Results affirm that hydrologic changes in WCA3B are minor (see also Tables 10 and 11).

21. The rain-driven formulas presented in the GDM take into account the varying amount of water. It is recognized that water is a limited resource. The project is designed to use this limited resources in the most efficient way. The distribution of water among competing users is the task of the local sponsor, the South Florida Water Management District.

22. The MRD plan sends more water to WCA No. 3A for the purpose of preserving and protecting the snail kite. As a part of this plan, the S-349's were modeled as being fully open to allow a free flow of water. However, the operation of these structures will be an important issue in planned operational studies.

23. Cited refers to the project construction. "Phase 1" refers to the order in which the project features could be constructed, not the phases in the plan development. The recommendation is for all project features to be implemented together since the project does not have any separable project features. WCA No. 3B is now isolated by the surrounding levee system. The majority of its water is received from direct rainfall. The return of WCA No. 3B to the everglades hydrologic system is a large part of returning the overall hydrologic restoration. The restoration is also part of the Parks seven point plan for restoration.

24. The figure is not intended to distort the readers into thinking the WCA No. 3A is as large WCA No. 3B. The purpose of Figure 2 is show the benefits of each plan and to which particular area these benefits are applicable. The return of WCA No. 3B to the everglades hydrologic system is a large part of the overall hydrologic restoration. The restoration is also part of the Parks seven point plan.

25. Tables 9, 10, and 11 are now corrected.

(26) Table 12. Results for wading birds refute GDM statements about improvements expected under raindriven plans. Effects on alligators are not significant.

MMD benefits the snail kite as well as the wood stork.

The finding of jeopardy is not pending; the Biological Opinion is in effect and is part of the GDM package.

Airboat access for the Miccosukee Tribe would be most improved under the MMD plan, not "no change".

(27) Table 13. It is not clear which interested parties were given the opportunity to review the MRD and MMD plans, in detail. The National Marine Fisheries Service and the Florida Game and Fresh Water Fish Commission are not even listed here, even though the Corps is required to solicit their views under the Fish and Wildlife Coordination Act. Both agencies have reviewed the plans and provided you comments, which apparently were ignored in the GDM.

The Miccosukee tribe expressed its view in terms of effects on their use of WCA3A (see letter appended to our FWCA report). Only the Base, MMD or MRD deliveries would satisfy their interests.

COMMENTS ON DRAFT EIS

(28) viii; par. 4. The statement that the BRD plan was found to jeopardize the snail kite should be preceded by some statement of rationale for this finding. This was, briefly, that the BRD plan significantly reduces hydroperiod of the kite's Critical Habitat, without replacing long-hydroperiod wetlands elsewhere in the Everglades.

The future iterative testing of water delivery plans will require modeling and data analysis as well as field testing. These will require a commitment of time and manpower from all concerned agencies.

(29) ix; par. 7. The Florida Game and Fresh Water Fish Commission is a participating planning agency which continues to express a preference for the MMD plan.

It should be noted that the performance of the MRD plan equals or exceeds that of the BRD plan for most objectives, reducing the significance of any controversy over the effects of the jeopardy finding by the Fish and Wildlife Service.

One major unresolved issue is the question of adequacy of water supplies for the Park, other portions of the Everglades, and consumers. Any of the 4 water delivery plans would have performed better had supplies been sufficient to extend hydroperiods in central Shark River Slough. Future competition over water supplies may preclude meeting the ecological objectives of the project, even though distribution and timing of water deliveries be improved.

26. Table 12 shows the results of each plan relative to the base condition. The statements in the GDM refer to the flexibility in the operation of the project structures for the benefit of the species.

27. The Florida Game and Fresh Water Fish Commission and the National Marine Fisheries Commission opinions are included in the Fish and Wildlife Coordination Act report. Table 13 is intended to show the views of the major interests involved, not all parties have expressed an opinion. The Miccosukee Tribe provided comments, but were not specific about each plan.

28. The FEIS text has been revised to reflect the comment.

29. The FEIS text has been revised to reflect most of the comments.

EIS-2. The objectives and authorities stated here are reasonable. They deal with restoration of hydrology in the Park, and do not expand project objectives to include a need to change conditions in WCA3A and WCA3B. In contrast, the GDM held that "restoration" of both areas were among the planning goals, and developed findings and recommendations based on that view. This is important, since the legitimate objectives can be met by a variety of water routings. Also, none of the four plans reviewed move more than 21 percent of the flows through WCA3B, anyway (see Table 7).

EIS-3; 2.03. The EIS should note that conveyance of water through WCA3B is not the only way to meet the Congressional mandate. S-333 could be used as an alternative route for delivering water to NESRS. Indeed, Table 7 of the GDM shows that the existing S-333 will be required to deliver 60 percent or more of the NESRS inflows. Both the National Marine Fisheries Service and the Florida Game and Fresh Water Fish Commission also recommend enlargement of S-333, either as an alternative to putting water through WCA3B, or to add "flexibility" to management opportunities. (30)

EIS-7; 2.20. This is a truer and more useful assessment of the status of the alternatives among the concerned agencies than was given in the GDM.

EIS-22; 4.06. This section should be rewritten to be accord with the data presented. The raindriven plans would reduce alligator nest flooding in the Park, and increase it in WCA3A, according to the Park's analysis (appendix to FWCA report). The productivity of WCA3B is currently "available to wading birds", and even supports its own wading bird nesting colonies. The Florida Game and Fresh Water Fish Commission, which manages WCA3B, holds that it is productive, diverse, and relative pristine. I find no evidence for the EIS statement that the "periphyton-forage fish-wading bird food chain has virtually collapsed in this area since it has been impounded." On the contrary, the Park (see appendix to our FWCA report) argues that loss of water supplies to the headwaters of the estuary are responsible for decline of the Park's wading bird colonies. Restoration of surface flows to the estuary may be maximized (within present water supply constraints) by using S-333, rather than routing flows through WCA3B. 31

EIS-22; 4.07. Running water through WCA3B would not appreciably change its hydrological characteristics, according to hydrologic modeling results presented elsewhere in the this document and by the Park. It is unclear what marshes along "the eastern edge" are referred to. The benefits to WCA3B appear entirely speculative and not highly relevant to the mandated objectives of the project. This section should be rewritten or deleted. (32)

EIS-23; 4.08. I agree that detention of flood waters in WCA3B has potential for benefitting hydrology of NESRS. The modeling (discussed on EIS-25), however, does not indicate that short hydroperiod wetlands are expanded under the alternatives examined, except for the MMD (which does not use WCA3B). (33)

EIS-27; 4.22 & 4.23. Dr. Tabb's arguments for specific depths and durations of flooding based on soils is particularly compelling; the conclusion which must be reached by the reader is that the volumes expected to be delivered to NESRS are inadequate. This is disturbing, but is (34)

30. Restoration of WCA 3B must be included in the project to fully meet the Congressional mandate (see response #19). The detention capacity of WCA 3B is needed to buffer the pulses of excess water moving through the system at times during the wet season that result in unnatural water conditions in the Park. The Minimum Structural Plan would not be able to take advantage of this capacity, thereby continuing the excessive or unseasonable regulatory releases that disrupt alligator nesting or water recession rates that are important to wading bird reproductive success. An enlarged S-333 would not be as effective in offsetting the need for the S-355s or in providing cost-effective flexibility. The proximity to S-12D and the removal of L-67ext. would combine to result in a rise in tailwater elevation at S-333 during times of high discharge, resulting in a decreased discharge capability that would effectively negate much of the desired results.

31. This paragraph is a discussion of the merits of a structural alternative without coupling it to any operational strategy. The [modeling] "data" referred to in the comment are not relevant to the discussion, which is in the context of potential improvement based on professional opinion of Park biologists and the experts assembled at the White Paper Workshop. There is essentially no field data available to assess the existing ecological conditions in WCA 3B relative to historical conditions. See also response 32, above, vis-à-vis S-333.

32. See response 34, above.

33. The comment fails to distinguish between modeled results of a time-constrained limited array of inadequate operational strategies and the potential results that experts believe to be possible when a wider array of operations can be formulated over the next several years to begin the iterative testing program and after field experience is gained during the iterative testing.

34. By Dr. Tabb's criteria, greater depths would need to be obtained in NESRS to reach historic conditions. This could be accomplished by a greater overall delivery volume or by providing a larger percentage distribution to NESRS of existing volumes. The appropriate approach will be developed through additional analysis during the detailed engineering design stage following the GDM.

supported by other appended analyses. Again, the GDM and EIS conflict on adequacies of water supply.

(35) EIS-35; 4.43. Analysis of water supply changes in Lake Okeechobee, made on a month by month basis instead of average annual, show that the MRD and BRD use less water than the Base (or MMD) during dry years (see p. D179-D185). The net annual effect is shown on page D83, in the Biological Opinion.

(36) EIS-38; 4.57. I do not find any evidence for the statement that inclusion of WCA3B would allow full restoration of NESRS. None of the modeled alternatives show that adequate volumes would be passed to meet this goal (see EIS-27, 4.23).

(37) EIS-38; 4.58. The wildlife models, whose development was funded by the Corps, were statistically validated using relevant field data, and operated on the best available predictions of hydrologic conditions in the project area. I am surprised that the Corps chooses to rely instead on intuition ("beliefs") to circumvent conclusions reached by rational analysis. The EIS notes that the "white papers" were not reviews of any real-world water delivery alternative, while the model runs did examine a range of possible delivery scenarios. I do not disagree that "restoration of natural hydrologic conditions in SRS" would benefit wildlife, but have not seen a water delivery plan using the proposed structures which would produce "natural hydrologic conditions"; see EIS-27, 4.23).

(38) EIS-40. I was not "primarily responsible for preparing this Draft Environmental Impact Statement", and request that my name be removed from this list.

SPECIFIC COMMENTS ON APPENDICES

(39) E-4. 4. How can stages for alternatives be "slightly the same"?

(40) E-5. 7b. We did not think that the MMD discharged into NESRS via S-333.

Sincerely,

Arnold Banner

35. The EIS paragraph on regional water supply impacts has been revised to encompass new analyses on the issue.

36. See responses #2 in National Audubon Society's letter (page F-18) and response #36, above.

37. The EIS has been revised to clarify the Corps' position that expert opinion is being relied on to assess the potential for ecological improvement that the recommended structures would provide once an appropriate operational strategy is developed. The wildlife modeling results are counterintuitive if they are thought to fairly represent that potential.

38. The EIS has been revised to clarify that the referenced responsibility refers to the role as shown in the table.

39. The GDM has been revised to read "slightly higher".

40. The GDM has been corrected.

FLORIDA WILDLIFE FEDERATION

Affiliated With National Wildlife Federation

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MANLEY K. FULLER III
President

October 18, 1990

Mr. A.J. Salem, Chief
Planning Division
Environmental Resources Branch
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232 - 0019

RE: GDM on Modified Water Deliveries to Everglades Nation Park with DEIS

Dear Mr. Salem:

These are the comments of Florida Wildlife Federation (FWF). Many of our 11,000 members make extensive use of areas affected by this project.

FWF is, of course, supportive of efforts to restore a more natural hydroperiod in Northeast Shark River Slough, but we do have some concerns about the manner of implementation.

1. We believe that the dispute about protection of the Everglades Kite must ultimately be resolved through generation of more a accurate hydroperiod model. We suggest that the Corps work with USGS, FWS and ENP to develop this model so that there is common agreement about predicted hydroperiod. Such a model would also be of great benefit in making other water management decisions concerning the Central and South Florida Flood Control Project. There are also biological questions that must be resolved by peer review. (1)

2. Because it has not previously been exposed to nutrients and other contaminants from upstream agricultural and urban sources, WCA-3B is more nearly pristine than other conservation areas. FWF believes that special efforts are required to maintain this condition. FWF recommends that the same water quality criteria as are developed by ENP under the Outstanding National Resource Waters regulations for discharges through the (2)

RESPONSES TO

Florida Wildlife Federation — Letter of October 18, 1990

1. In realizing the limitations of the model, the GDM proposes that structure operations be developed through an iterative testing procedure. It is also proposed environmental and hydrologic monitoring be conducted to refine structure operations for providing the best hydrologic conditions to the everglades. The difference of opinion between the various agencies is not based on the hydroperiod itself, but rather whether the changed hydroperiods will have a positive or negative effect.

2. See response to comment #2 in F.A.D.E. letter (page F-4). The criteria adopted will be consistent with the outcome of the federal water quality lawsuit.

S-12 structures be adopted for discharges into WCA-3B. If the Corps chooses to adopt less stringent criteria that will allow water quality degradation, it should be prepared to show that these will not violate state water quality standards. Water quality is probably a function of antecedent conditions, stage, flow, etc. Releases will be harmful under some circumstances, but not others. The model described in No. 1 will be useful for this purpose.

(3) 3. As the system now functions, rain that falls on WCA-3B nourishes the Everglades ecosystem in that area. FWF is concerned that WCA-3B may be deprived of this benefit through withdrawals, either directly or indirectly, to supply urban wellfields and south Dade agriculture. Natural systems are already suffering as the result of SFWMD water allocation policies. FWF requests that the Corps develop operation procedures that insure that this project does not result in loss of water from natural areas to supply additional water for other uses. The model proposed in No. 1 will be useful for developing these operational criteria.

(4) 4. FWF members are extremely concerned that impediments to navigation proposed in this project will deprive them of recreational opportunities they now enjoy. FWF urges the Corps to develop navigation alternatives that do not significantly diminish recreational access to any part of the Project.

FWF believes that each of these problems can be resolved with a minimum delay in implementing this important project.

Thank you for considering our comments.

Sincerely yours,

Manley K. Fuller III

Manley K. Fuller, III
President

3. As stated correctly, the South Florida Water Management District is responsible for water allocations in the C&SF project. However, the Secretary of the Army is responsible for ensuring that the proposed project features fulfill the authorized purposes. As structure operations develop through the iterative testing process, a criteria would also develop to insure the project functions for the restoration of the everglades. However, the proposed project deliveries are based on local rainfall. Consequently, there would be times when water is not abundant, thus ENP would share adversity with other users.

4. See response to comment #1 in F.A.D.E. letter (page F-4).

Yale University New Haven, Connecticut 06511

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Mr. A. J. Salem
Planning Division, Environmental Resources Branch
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

19 October 1990

Dear Mr. Salem,

Thank you for the opportunity to comment on the General Design Memorandum on the Modified Water Deliveries to Everglades National Park (GDM) and Draft Environmental Impact Statement (DEIS). The document is a thorough compendium of the scientific review process that has in regard to this policy decision. I have only several points to make about the document.

Of the Endangered Species in the Everglades region, the Snail Kite is the candidate most likely to be adversely affected by the changes proposed in the GDM. In fact, the kite's needs required that the originally proposed Raindriven management scheme had to be modified so that it would be acceptable under the Endangered Species Act. With this in mind, it is critical that the kite population be monitored in a robust fashion. Data should be gathered in relation to water levels that would allow for good demographic and ecological models to be completed and validated. Such information and models will be critical for making future water management decisions.

The monitoring program as described in the GDM (pages 42-46 and C-19) is not sufficient to meet these needs. Surveys and intensive studies will need to be carried out throughout the southern Everglades and not just in Everglades National Park, where the bird has rarely ever nested and has been an irregular visitor. It is especially critical that the kite population in Conservation Area 3A and 3B be monitored from ground studies because aerial surveys can not yield accurate results for this species.

It is inadvisable to assign the primary responsibility for gathering this important set of data on Snail Kites to Everglades National Park. The Park has too much vested interest in water management policies (e.g., rewatering East Shark Valley Slough) that are likely to affect directly the areas of the Everglades immediately upstream areas from the Park. (1) This area is the federally registered Critical Habitat of the Snail Kite protected by the Endangered Species Act. The U.S. Fish and Wildlife Service may not be prepared to assure the type of monitoring effort that will be required to address the Corps needs. Properly monitoring the kite population is so critical to the Corps' future success and implementation of the GDM that the U.S. Army Corps of Engineers itself should take responsibility for the implementation of this program. The precedent exists since the Corps funded studies in this area from 1986-1988.

Sincerely,

Steven R. Beissinger
Assistant Professor of Wildlife Ecology

RESPONSES TO

Dr. Steven R. Beissinger — Letter of October 19, 1990

1. As the Federal "action" agency, the Corps is responsible for obtaining adequate data that can be used in the decision-making process. At the present time, the USFWS and the Park are developing an MOU addressing data collection and evaluation methods that could be used in the assessment of impacts to endangered species within the Park and adjacent areas. The Corps will evaluate the applicability of these methods when they have been developed.. If additional data are required for the Corps' decision-making, then the Corps would be responsible for obtaining them.

FLORIDA GAME AND FRESH WATER FISH COMMISSION

WILLIAM G. BOSTICK, JR. Winter Haven
DON WRIGHT Orlando
THOMAS F. HIRES, SR. Lake Wales
MRS. GILBERT W. HUMPHREY Milwaukee
JOE MARTIN HILLIARD Clewiston

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STATE CLEARINGHOUSE

October 19, 1990

Ms. Karen MacFarland, Director
Florida State Clearinghouse
Executive Office of the Governor
Office of Planning and Budgeting
The Capitol
Tallahassee, Florida 32399-0001

RE: SAI #FL900808020RC, Modified Water Deliveries to Everglades National Park, Draft GDM and EIS

Dear Ms. MacFarland:

The Florida Game and Fresh Water Fish Commission has reviewed the referenced documents, and offers the following comments.

The goal of this project is to improve water deliveries to Everglades National Park (ENP), via structural changes in the Central and Southern Florida water management system, to more naturally distribute the inflow across Shark River Slough. An interim operating plan based on rainfall-driven deliveries has been developed, but the ultimate operational strategy will presumably be defined over the next few years.

The Game and Fresh Water Fish Commission fully supports the goal of redistribution of inflows to ENP across the full width of Shark River Slough. This measure, in concert with ENP acquisition of Northeast Shark River Slough, will begin the critical process of hydrological restoration required for the survival of ENP's unique natural resources.

We are, however, concerned with certain aspects of this project that could adversely impact Conservation Area 3B (CA3B) and seriously interfere with recreational use of L67A. The plan calls for a portion of the water going to Northeast Shark River Slough (approximately 24%) to be delivered via sheet flow across Water Conservation Area 3B (CA3B). This would be accomplished by placing three structures (S-345 A, B, & C) across the L-67A

canal to back up canal flows and force water through culverts in the levees separating CA3A from CA3B. The rationale for this proposal is the restoration of a more natural sheetflow condition in CA3B, which is nearly isolated from the remainder of the water management system and is currently supplied mostly by rainfall. The GDM and EIS refer to "ecological restoration of CA3B" which would take place with the flow-through system, although no data are presented to support this conclusion. In fact, CA3B may be the most pristine example of Everglades remaining in the system, precisely because it has been isolated. It has excellent Everglades wildlife habitat and good water quality. (1)

If diversion across CA3B is to occur, it must not adversely change the hydrology or degrade the water quality currently existing in this area. The models predict minimal hydrological impact, but, to prevent any future possibility of adverse changes, an ecosystem-based regulation schedule should be developed for CA3B. Water quality data from the South Florida Water Management District reveal that phosphorus concentrations in the L-67A canal tend to be lower during the higher water stages when the S-345 structures would be utilized. However, they are still considerably higher than background marsh values, and we are concerned about the potential for adverse ecological shifts in CA3B due to diversion from L-67A. If the Corps of Engineers proceeds with this diversion across CA3B, we strongly recommend that it be done only when water quality in L-67A approaches that of the background levels in CA3B marsh. If this is not possible, we recommend that all water be delivered to Northeast Shark River Slough through structure S-333 (at the south end of L-67A) and L-29 (this mode of delivery would supply 76% of the volume under the proposed plan). (2)

Another concern we have with this portion of the project is the impact of the three S-345 structures on recreational use of the L-67A canal. As presently designed, the structures would block all boat traffic in the canal, isolating boaters to the areas north, or south, of the three structures. The L-67A canal is the most popular fishing area in the Everglades, with 100 to 200 boats present on a busy weekend day. A preliminary survey conducted in 1988 revealed that approximately 200,000 man/hours of fishing took place in L-67A during the late winter-early spring prime fishing period. Boaters routinely access the entire length of this canal, whether they launch at the north or south ends. The structures, as proposed, would seriously interfere with this recreational use. (3)

If the diversion of water across CA3B can meet the recommended water quality criteria described above and the Corps of Engineers proceeds with this option, we recommend that any structures constructed in L-67A not be permanent impediments to boat traffic. Our first choice would be that no canal-blocking structures be built, but that water be routed from CA3A to CA3B through a

RESPONSES TO

Florida Game & Freshwater Fish Commission **Letter of October 19, 1990.**

1. The rationale is to bring WCA 3B back into the Everglades system (as requested by the Park as part of their 7-Point Plan) to enable restoration of the historic flow patterns to and through the Park. Experts at the White Paper Workshop believed that this is essential in order to improve ecological conditions in the Park, and that it would also bring the entire Everglades system to a more natural, restored condition, including the WCAs. This is not supported by data because, to our knowledge, none exist that would allow a comparison between existing and historic ecological conditions in WCA 3B.

2. It could be expected that an operational strategy that would restore natural water flows through the Everglades would alter the hydrology of WCA 3B, since it is now an impounded, isolated system. A change towards natural would not necessarily be considered adverse. Establishing an independent regulation schedule for the area could be inconsistent with the natural flow concept. Any proposed new operational strategies developed in the future would be subject to NEPA review. With regard to water quality concerns, see response to comment #2 of the Florida Wildlife Federation of October 18, 1990. The referenced SFWMD water quality data is the best available, but it should be recognized as having limited relevance to the issue. The collection location is at the headwater of S-151 at the crossing of the Miami and L-67A canals. Water quality at this site is heavily influenced by discharges from S-9 which pumps out of the largely developed C-11 Basin. This results in poorer water quality at this location at higher stages because that is the time when S-9 is pumping the most. Further south in the L-67A Canal where the recommended S-345 structures are located, there would be a better inverse relationship between stage and degraded water quality.

3. See response to comment #1 of F.A.D.E. letter (page F-4).

series of culverts in the L-67 levees. If structures are built, they should include openings, or notches, for boat access or, as a last resort, bypass channels.

Sincerely,

Colonel Robert M. Brantly
Executive Director

RMB/BSB/rs
ENV 1-3-2
cc: A. J. Salem
Chief, Planning Division
U. S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0012

Lt. Colonel Robert D. Dunford, GFC, West Palm Beach

South Florida Water Management District

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EOF: ADM 14-06 RF: 90384

October 19, 1990

Colonel Bruce A. Malson
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Colonel Malson:

The District appreciates the opportunity to review and comment on the GDM for Modified Water Delivery to Everglades National Park (ENP). We recognize the difficulty in bringing together divergent interests and opinions on issues of water supply to ENP. The proposed redistribution concept and adoption of a rain-driven delivery schedule is a major step toward achieving more natural flow to the Park while meeting the flood control demands of South Florida. While the District supports the construction elements of the recommended plan, we have serious concerns over several key issues as outlined below. Additional comments are provided in the attachments.

Our greatest concern is the unconditional acceptance of the modified rain-driven (MRD) plan, if consensus on alternate operating criteria can not be reached. This precondition reduces incentives for interagency coordination to balance competing interests of the agencies involved. We remain strongly opposed to any federal requirement to use the state's water supply to maintain an unnatural impoundment on state land. Moreover, there is no consensus that the MRD plan would provide greater environmental benefits compared to the basic rain-driven (BRD) plan. Analysis by ENP staff indicates the BRD plan would be more beneficial to a wider variety of threatened and endangered species while meeting the hydrologic restoration objectives for Shark River Slough. (1)

The MRD plan did not include a rigorous analysis of several significant potential impacts. There is a single paragraph on page EIS-35 which addresses the effects of the MRD plan on Lake Okeechobee water supply. We strongly disagree with the conclusion that the MRD plan does not have a significant impact on regional water supply. The report indicates an average annual increase in demand on the Lake of 54,000 acre feet with the MRD plan. Presumably the amount would be higher in a dry year although the analysis to determine this is not presented. As the agency charged with managing water supply for south Florida we do not view any increase in demand on the lake as insignificant. We brought this issue to your attention in our previous comment letter and the GDM only reinforces our position. (2)

The MRD plan suggests quality of water flowing to the Park would be improved by restoring sheet flow through WCA-3B. Water released to the Park now is, and should remain of good quality. We are not aware of any data that would indicate the quality of water entering the Park through WCA3B would differ from that entering through WCA3A. However, the MRD plan could introduce additional nutrients to WCA-3B and the Park. Supplemental water demands will be greatest during low water or drought conditions and would require moving water through canals, thus bypassing the Everglades marsh where nutrients would normally be removed by vegetation. This added risk of introducing canal water to the Park would not occur under the BRD option. (3)

Governing Board
James E. Garner, Chairman, Fort Myers
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John R. Wodraska, Executive Director
Tilford C. Creel, Deputy Executive Director
Thomas R. MacVicar, Deputy Executive Director

RESPONSES TO

South Florida Water Management District Letter of October 19, 1990

1. The Corps cannot recommend a structural plan without an accompanying operational recommendation for the new structures. Recommendation of the BRD Operation is blocked by the conflict with the Endangered Species Act. The MMD Operation is not acceptable to the Park. The only remaining operational plan that could be developed within the GDM time constraints is the MRD. By elimination, it must be the recommended operation pending future coordination on formulating a better plan. The lack of consensus on this operation should provide increased incentives to better formulate alternatives.

2. More data is shown in the GDM regarding the water supply issue. These data show no significant changes in storage occur with all alternatives analyzed.

3. If water quality entering the Park "now" (Base Condition - minimum delivery schedule) is of good quality, it would also be so under the MRD Operation because, under both scenarios, water is brought to the S-12s during dry periods through canal flow. The supplemental water brought down under the MRD Operation would not be released to the Park until rainfall triggered a delivery and dilution had occurred. Nutrients responsible for current water quality concerns enter the system from areas upstream of WCA 3A. Such areas are under State control, and solutions to the nutrient runoff problem are being addressed through the Everglades SWIM Plan and U.S. vs SFWMD.

The MRD Plan also fails to recognize or balance the potential environmental impacts to WCA-3A of maintaining artificially wet conditions for prolonged periods. Our experience with prolonged hydroperiods in WCA-2A produced a number of negative environmental effects, including loss of important vegetation species that are difficult to restore once the ecosystem has been altered. Operating conditions that increase the risk of similar impacts in WCA-3A would be counter to the objective of enhancing the ecological function and stability of the total Everglades system. (4)

While the District recognizes and agrees with the concept of reintegrating WCA-3B as a contributing basin for flows to Northeast Shark River Slough (NESRS), there are several technical considerations not addressed in the proposed plan. Results of the two-year field test indicate desired discharges to NESRS could not be achieved during the wet season with L-29 canal stages at 7.5 ft. Sustained stages above this level may cause structural problems for US 41. Contrary to the assertions in paragraph 4.44 of the EIS, further coordination is needed with the Department of Transportation to insure that future water deliveries are not constrained by structural limitations of US 41. (5)

You are no doubt aware that the S-349 structures proposed for the L-67 canal are strongly opposed by local fishermen. While we do not oppose consideration of these structures, we feel the navigation concerns are legitimate. We would recommend these structures be retained as a design option, but defer construction until the remaining elements have been completed and an operational test period has been conducted. We would like you to consider simple breeches to the L-67A and L-67C levees and partial filling of the associated canals as an interim measure. Enhanced diversion from WCA-3A to WCA-3B could still be accomplished and modifications to the L-67 canal completed at a later date, if field test results indicate plan objectives would be compromised without the S-349 structures. (6)

Since the structural features in the MRD and BRD plan are identical, the District will support continued development of additional Design Memoranda necessary to complete the construction elements. We can not accept the operational constraints advocated under the MRD plan until a detailed analysis is performed and the potential impacts are known and found acceptable. We will continue to work with the Corps in resolving technical and policy differences to insure all the interests of South Florida are equitably served. (7)

Sincerely,

John R. Wodraska
Executive Director

Att.

4. It is generally recognized that the MRD Operation is far from ideal on a number of accounts. Maintenance of an artificial impoundment in WCA 3A is one of them. This does not seem of overriding importance considering that the impoundment has existed for nearly 30 years and the plant communities have stabilized (your comment #13, below). The MRD Operation would reduce the extent of permanent standing water occurring under the Base Condition and increase the frequency of dryout, according to the USFWS analysis.

5. Maximum stages in L-29 would increase the mean about 0.4 feet above those of the base condition (see Main Report Appendix E). However, USGS records show Tamiami Trail was subjected to stages similar to those that would be generated by the project. The mean of actual stages (1953-62 period) would be about 0.1 feet below than the MRD maximum stages mean. DOT has been repeatedly queried on this subject, and as stated in the DEIS, has not yet responded. Neither did they provide such comments during this NEPA review. Further coordination with DOT will be conducted.

6. The recommended plan has been modified to include by-pass channels around the S-349 structures in the L-67A Canal to permit recreational navigation while allowing the diversion of water to meet the project purposes. Partial canal filling would compromise water deliveries from Lake Okeechobee to WCA No. 3A for environmental reasons, water supply to the ENP/South Dade Conveyance System for domestic and industrial use, and water supply to ENP during fires in the dry season. WCA No. 3A is used as a reservoir for providing water (as primary source) for various purposes including water supply to South Dade County and ENP, salt water intrusion, and others. Breaching Levees 67A and C would result in uncontrolled flows into WCA No. 3B, causing severe losses in the reservoir. Also, breaching of the two levees would negate seepage control and would induce unnecessary flood risks to the areas east of L-30.

7. Structure operations will be developed through an iterative modeling and testing period. The Modified Rain Driven alternative will only be used if no other operating strategy can be agreed to by all parties. However, as discussed in response to your comment #1, above, it is a necessary part of the recommended plan and, as such, must be accepted by the Local Sponsor in order for the project to receive Congressional authorization.

Attachment
Col. Malson Ltr.
October 19, 1990

Technical Review of ENP Water Delivery GDM

(8) page 8 - wading birds/fisheries - statement should include importance of hydroperiod and natural drawdowns as a controlling mechanism concentrating fish and other prey items for wading birds.

(9) page 9 & 10 - historic conditions - The description of water flowing from Lake Okeechobee may be misleading and implies in the following sentence that this flow may have contributed to sheet flow in the Northeast Shark River Slough. Although surface flow to Florida Bay and adjacent estuaries may have ceased during dry conditions, ground water gradients continued to contribute some level of baseflow and helped reduce coastal salt water intrusion.

(10) page 15 - S-12 Water Quality - Total P concentrations vary seasonally with annual rainfall amounts and are often higher following periods of severe drought. Average seems to vary somewhere between .015-.020 mg/l.

(11) page 16 - Fisheries - 4th sentence is a non-sequitur - suggest adding "In contrast," to beginning of sentence.

(12) page 20 - The Everglades SWIM Plan also recognizes need for appropriate timing and distribution of water quantity.

(13) page 20 - Periphyton & Vegetation - Plant communities along L-67 and in the southern portions of WCA-3A have already stabilized in response to flooding conditions imposed by current regulation schedules. Shorten hydroperiods and increased fire frequency/severity are a more likely threat in response to competing demands for water.

(14) page 29 - Flow-Through (FT) Plan - Plate 6 should be referenced at the end of the second sentence.

(15) page 30 - (8) Seepage Levees - 5th sentence, should read head difference across L-30 from S-335 to Tamiami Trail was increased by 1 to 1.5 feet.

(16) page 31 - a. Reason for Phase - sentence 2nd from bottom; There is no current legal agreement between the District and local agricultural interests. Prior agreements defining the operation of S-333 during the 30 and 90 day, and two year test periods have expired in 1987.

(17) page 36 - (2) Operation Modifications - bottom of 2nd paragraph; A description of the transition zones in the WCA-3A regulation schedule should be included.

(18) page 36 - c. Description of MRD Plan - The gauges should be identified that will be used to compute the average stage in WCA-3A as equal to or below the target 9.0 feet.

(19) page 40 - Summary - 2nd paragraph from bottom, 2nd sentence; Should read "Although the MRD plan is not supported by all groups listed ....."

(20) page 40 - Summary - last paragraph, 2nd sentence; "The alternatives are

(21) page 48 - top of page, first paragraph, last sentence; alos should be also.

(22) Monitoring requirements should be expanded to include documenting vegetation impacts in WCA-3A resulting from the Lake Okeechobee supplements and maintenance of a 9.0 NGVD stage for Everglades Kite habitat. Monitoring requirements should additionally include documenting vegetation changes in

8. The GDM has been revised to reflect the comment.

9. The statistics cited are average and are not linked to either wet or dry seasons. However, additional language was incuded to reflect your view. Suggested statement about ground water is included in the GDM.

10. The GDM has been revised to reflect the comment, except the average is stated as varying between .008-.013 mg/l.

11. Suggested language is included in the GDM. Sentence now reads: "In contrast, high water conditions... available to wading birds".

12. The paragraph limits discussion to water quality, the discussion of timing and water quantity is elsewhere in the GDM.

13. The GDM has been revised to reflect the comment.

14. Plate 6 refers to the Basic Rain-Driven Plan.

15. The GDM has been revised to reflect the comment.

16. The GDM has been revised to reflect the comment.

17. The GDM has been revised to reflect the comment.

18. The GDM has been revised to reflect the comment.

19. The GDM has been revised to reflect the comment.

20. The GDM has been revised to reflect the comment.

21. The GDM has been revised to reflect the comment.

22. See response to comment #4 in Dr. Frederick's letter of September 7, 1990. These recommendations can be considered during the coordination meetings.

Attachment
Col. Malson Ltr.
October 19, 1990

marsh areas surrounding S-349 resulting from forced overland flow by these structures.

(23) Due to the significant change in hydroperiod in WCA-3B that will result from the addition of water from WCA-3A, monitoring of the environmental impacts in WCA-3B is strongly recommended. Monitoring of impacts to WCA 3B were specifically suggested in the Appendix C Analysis of Environmental Benefits to ENP from Hydrological Restoration of Shark River Slough.

(24) page 50 - paragraph top of page - Stated improvements for water quality can not be achieved during dry season conditions when canal flows may be the dominant mode of water delivery to ENP.

(25) page 50 - Periphyton - Statement purporting a historical trend of increasing nutrient loadings to ENP is not documented.

(26) page 53 - First Increment - Description of incremental benefits are somewhat vague and confusing. Paragraphs seem to alternate between focusing on what damages or negative benefits are associated with the base condition and identifying some of the drawbacks associated with the recommended plan.

(27) page 54 - Second Increment - 4th sentence from bottom of section; It is not clear that the proposed improvements will significantly enhance dry season hydroperiod.

(28) page 56 - Description - The S-333 structure is an integral part of the rain-driven delivery system, providing supplemental flows when target deliveries from S-355 can not be obtained. Will additional improvements at S-333 be required in order to operate with new stage conditions in L-29. These improvements are not incorporated into the current GDM. Will the District be responsible for these improvements and any associated permits?

(29) page 57 - Rainfall Response Component - Use of a rainfall formula to compute ENP flows will require periodic modifications to incorporate new information and refinements. Additional language should be included to authorize implementation of these refinements through mutual agreement of the District, ENP and COE.

(30) page 59 - S-355 - Recommend the collection canal proposed for S-355 structures be constructed with steep slopes to reduce potential habitat for cattail growth. Design tailwater elevation as described in the "Pertinent Data" section will generate very high seepage losses to the east. Has the additional seepage been considered in the operation of S-335?

(31) page 65 - Pump Stations - second paragraph; S-356 will begin pumping when the canal stage in L-31N reaches 5.5 ft NGVD. Under the District Interim C-111 plan, a new structure G-211 was proposed to reduce seepage loss from NESRS by maintaining 5.5 - 6.0 ft NGVD. Will improvements to S-331/S-173 be required to maintain the higher canal levels if G-211 is removed? Would continued use of the G-211 or similar structure enhance flexibility of water control during dry season conditions in conjunction with the S-356 pump station? Dade county is interested in G-211 as a permanent structure to improve recharge to the proposed west wellfield.

(32) page 78 - Project Regulation - Analysis and testing studies are mentioned. Will these studies be the responsibility of the Corps or jointly with the District and other agencies?

23. See response #22, above.

24. Since water deliveries would be based on a rainfall driven formula, water deliveries under dry conditions would be expected only under unusual weather conditions.

25. The documentation is contained in Statement #84 in Plaintiff's Statement of Undisputed Material Facts, 11-19-90; U.S. v. SFWMD, et al.

26. The incremental analysis is a requirement in our planning regulations for which an attempt is made to analyze the recommended plan by breaking it into increments whose benefits can be separately defined. By so doing, it should be possible to show what each increment adds to the overall plan, and by subtraction, what benefits would be lost if a particular increment was dropped.

27. In conjunction with an appropriate operating criteria, proposed improvements would restore dry season hydroperiods.

28. Improvements at S-333 would not be necessary for discharges to NESRS. The proposed S-355's and existing S-333 structures would have a combined maximum capacity of over 3,200 cfs. Supplemental flows through S-333 would occur only after the S-355's maximum capacity have been exceeded. Occasionally, S-333 would discharge during the dry season when low stages in WCA No. 3B would not allow discharges at the S-355's. Since the project is for environmental enhancement, any future improvements after the project is completed would need additional congressional authority and funding. If improvements are needed before the project is completed, FDM's could be used as a vehicle for requesting approval of modifications and additional funds. The local sponsor would be responsible for the O&M non-Federal share.

29. The GDM has been revised to reflect the comment.

30. The collection canals for the S-355's were designed with a slope of 1 vertical on 1 horizontal. During the FDM, steeper slopes can be analyzed. For seepage comment, see response to comment #15 in Ghioto letter (page F-60).

31. With input from the SFWMD, ENP, and others, the impact of removing G-211 would be evaluated during the iterative process. It may be determined that the existence of G-211 will enhance the flexibility of the new project works. However, all modeling to date has not included G-211.

32. PL 101-229 states that the Secretary of the Army in consultation with SFWMD will make a determination whether there are adverse impacts. It is anticipated that any studies would be conducted jointly although the Corps would take the lead in preparing the appropriate documentation, including NEPA documentation. All regulations changes in the C&SF project would follow established procedures. However, a successful study would need the participation and cooperation of other agencies. The SFWMD, ENP, and other agencies are expected to be involved in the process and play a major role in shaping the course of the study.

TROPICAL AUDUBON SOCIETY, INC.
5530 Sunset Dr., Miami, FL 33143
Phone (305) 666-5111
THE VOICE OF CONSERVATION IN SOUTH FLORIDA

October 25, 1990

Jacksonville District, Corps of Engineers
P.O.Box 4970
Jacksonville, Fl. 32232-0019

Attn.: A. J. Salem, Chief, Planning Division

Dear Mr. Salem:

We have reviewed the General Design Memorandum and the DEIS for MODIFIED WATER DELIVERIES FOR EVERGLADES NATIONAL PARK, FLORIDA. We have also attended the hearing in Miami on October 22, 1990.

The General Design Memorandum represents a practical implementation of three important requests contained in the Seven Point Plan which Jack Moorehead, superintendent of Everglades National Park, presented to the board of the South Florida Water Management District in March, 1983. These three requests were: to fill in L-67 extension, to restore conservation area 3B to the Everglades system and to distribute water deliveries evenly along the full length of the Tamiami canal. The GDM is also in substantial agreement with the recommendations of the East Everglades Resource Planning and Management Committee which were issued in April, 1985, and which were adopted by governor Graham and the cabinet. Finally, the GDM represents a current consensus between the Corps of Engineers, the South Florida Water Management District and Everglades National Park.

We fully support the General Design Memorandum and urge its implementation without delay.

(1) When a request for funding is prepared for presentation to Congress we urge that adequate amounts be included to sustain the scientific work which will be necessary to make the iterative testing process work.

RESPONSES TO

Tropical Audubon Society, Inc. Letter of October 25, 1990

1. Funding for the hydrologic monitoring will be requested by the Corps of Engineers. However, the responsibility for funding and implementing an ecological monitoring program would be the responsibility of others. ENP, the SFWMD and FGFWFC are expected to participate in this process.

We are aware of the request of bass fishermen that the canals L-67A and L-67C be kept open to navigation. We are supportive of this request as long as its implementation does not detract from the more important goal of reintegrating conservation area 3B into the Everglades system. Since the borrow canals L-67A and L-67C are accessible from either the northern or the southern end fishing in these canals can continue even if the proposed structures were to prevent the passage of boats. (2)

Sincerely,

Karsten A. Rist

Karsten A. Rist
Conservation Chairman

2. A discussion of the navigational issues and the recommended solution has been added to the FEIS. The L-67C Canal is accessible to boaters only from the southern end. Even with access from each end of the L-67A Canal, the revised locations of the S-349 structures would block boaters from the central 7 miles of the canal if bypasses were not provided. The recommended plan has been revised to include small boat channels with the S-349 structures. This added feature would maintain boating access along the L-67A Canal without adversely impacting the project objectives.

SIERRA CLUB The Florida Chapter

26 October 1990

US Army Corps of Engineers
PO Box 4970
Jacksonville, FL 32232

Dear Dr. Moulding:

Enclosed are the Florida Chapter of the Sierra Club's comments regarding the Draft General Design Memorandum and Environmental Impact Statement. These comments are submitted independently of the more general comments provided by the Everglades Coalition (of which we are a member organization). Thank you for the opportunity to respond and please contact me if you should desire clarification of any issues.

Sincerely,

Craig Diamond
Everglades Chair,
and responding for the
Southeast Office of the
Sierra Club

cc. R. Montieth, Conservation Chair
T. Woody, Southeast Office

"When we try to pick out anything by itself, we find it hitched to everything else in the universe." John Muir

COMMENTS OF FLORIDA CHAPTER OF THE SIERRA CLUB
REGARDING THE DRAFT GDM AND EIS --
MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK:

The Club greatly appreciates the extensive effort that went into the production of the EIS. It is comprehensive and provides adequate information on each of the alternatives presented.

From the perspective of the Club's interests and its past positions on the matter of Everglades restoration, only two alternatives may be considered of the six identified.

It is apparent from the EIS and from the individual agency and related research submissions that of the alternatives evaluated the Modified Minimum Delivery alternative (MMD) will provide the greatest benefits to all wildlife (wading birds, wood storks, and kites in particular) while increasing total deliveries to the Park without an increase in Lake Okeechobee water supply releases. Further, based on Florida Game and Fresh Water Fish Commission concerns, this alternative will maintain the existing high integrity of WCA 3B in terms of water quality. Last, it will require the least expenditures for structural improvements and the least loss of direct taking of wetlands. In the context of Federal and Club policy (no net loss), the MMD alternative remains attractive.

The Club, however, is of the opinion that the inclusion of WCA 3B as part of the improved spatial flow into the Park is a key step towards emulating original conditions. Another important component in restoration is the timing of deliveries. The MMD alternative addresses this in part, but makes no little to no allowance for natural, but atypical or extreme patterns of annual rainfall. Last, it is apparent that overall the Park has become water-starved. The MMD alternative does not result in substantially greater total deliveries to the Park.

Of the alternatives including the new role for WCA 3B and addressing natural patterns of rainfall, the Modified Rain-Driven alternative (MRD) appears to resolve better the issue of flow adequacy to Florida Bay. Often neglected in discussions about the hydroperiod of the Park and the Conservation Areas, the integrity of the tail-end of the ecosystem may serve as the best interim measure of overall system health. A large portion of the Park's overall wading bird population is dependent on food resources within Florida Bay, and these resources are most productive at moderate salinities, not at the extremes generated by the existing or the MMD schedules. Thus, the alternative which produces the most favorable conditions at the end may be assumed to produce reasonable or optimal conditions upstream (given the system in the shape that it is in).

While the Club shares the Game and Fish Commission's strong concerns regarding the impacts of the rainfall-driven alternatives on water quality in WCA 3B, implementation of the SWIM plans for Lake Okeechobee, the Conservation Areas, and the Park will, to an as yet unknown extent, improve downstream water quality so that concerns regarding the degradation of WCA 3B may be moot. For this reason, we concur that immediate implementation of the MMD alternative as a component of the MRD plan is worth pursuing. Water quality considerations may be more fully understood or resolved by the time the other phases of MRD construction are undertaken. (1)

The Club strongly believes that no additional risks be attached to the survival of the Everglades Kite and the recovery of the Wood Stork population as an indicator for wading birds in general, and it recognizes the drawbacks of the MRD in this regard. The expanded hydroperiods and improved soil conditions of the MRD alternative, however, may ultimately provide sufficient conditions to maintain or enhance existing populations. As USFWS noted in their report, while habitat is not maximized and the number of drying events is increased, there are increases in hydroperiods at locations other than where the primary assessment took place.

With regard to supplemental releases from Lake Okeechobee required to support the MRD alternative, this circumstance will have the benefit of minimizing excess freshwater flows to the St. Lucie and Caloosahatchee estuaries -- a system-level concern not addressed in any manner in the DEIS. Guaranteed deliveries to the park will encourage both agriculture and urban interests to conserve water to minimize the degree of conflict during occasional droughts.

While the Club generally prefers the alternative with least structural components, the need for flexibility in water management is crucial in this region until we understand more fully how to integrate the hydroperiod and water quality requirements of individual species with the behavior of the overall ecosystem. In principle, there should be no distinction in this regard, however, we recognize that we continue to deal with a fragmented system. Consequently, infrastructure flexibility must be linked with ecosystem knowledge to make the system workable. Opportunity for adjustments must be provided to address conditions (predicted or ocurring) which weaken species nesting or feeding habitat.

We concur with the Everglades Coalition that broader spacing of the S-345 and 355 structures may provide better sheetflow. However, we do not agree with the Coalition statement that NESS deliveries should be increased to as much as 75% of the total: historical conditions indicate a split of about 58/42, which is not grossly different than the 53/47 proposed by the MRD. In addition, an incremental approach to restoration may be useful in avoiding system shock. Last, expansion of the S-333 will meet NESS flow objectives (in the interim) until the water quality issue surrounding WCA 3B is resolved. (2)

RESPONSES TO

Sierra Club, Florida Chapter — Letter of October 26, 1990

1. The MMD is not a component of the MRD, but rather a separate operating plan. The GDM proposes the structural features that will allow restoration of the Everglades. Operations of the structures will be developed through an iterative testing process to maximize project benefits. However, if all parties cannot agree on an operating strategy, then the MRD operating plan will be used. Until all the project features are constructed, the current operating criteria of the restricted rain-driven plan would remain in effect if Congress extends the authority beyond 1991. As features are built, consideration may be given to incorporating them into the restricted rain-driven operation if modeling indicates that this would be beneficial to project objectives without adverse effects on other resources. Water quality constraints will be incorporated into operating criteria for the S-345's, the structures discharging into WCA No. 3B. This will prevent potential water quality problems in WCA No. 3B that may occur until the full benefits of the SWIM Plan are realized.

2. Since coordination of the draft GDM, the S-345's and S-349's were relocated and spread farther apart. This change is reflected in the revised GDM. Currently, S-333 is delivering water to the NESRS area. Enlarging S-333 is not necessary at this time since flows are restricted to protect the East Everglades. The future operating criteria will consider water quality an important parameter in the restoration of the Everglades.

(3) We strongly believe that the final GDM and EIS affirm water allocations and schedules for the Conservation Areas and the park. We understand that implementation will be an evolving process: the knowledge needed to support this evolution can only come from continuous and active monitoring of flow, stages, habitat, and populations. A committed funding strategy and schedule of agency responsibilities (federal and state) must be attached to the final report. It would behoove the Corps to undertake the lead role in coordinating and assigning this most difficult and essential task.

3. Environmental monitoring will be critical to the ultimate success of this project. In order to establish the most comprehensive monitoring program, the resources of a number of agencies will be required, primarily from ENP, SFWMD, and USFWS but also others such as FGFWFC, National Audubon, Universities, etc. Preliminary coordination of these efforts has been initiated. Additional coordination and planning will be required to determine the most efficient program and to distribute responsibilities among participants.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET NE
ATLANTA, GEORGIA 30365

OCT 2 1990

REF: 4WMD/WQMB/EMH

Colonel Bruce Malson, District Engineer
Jacksonville District, U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232

Subject: Draft Environmental Impact Statement (EIS) on Modified Water Deliveries to Everglades National Park, Florida

Attention: Dr. John Moulding

Dear Colonel Malson:

Pursuant to Section 309 of the Clean Air and Section 102 (2)(C) of the National Environmental Policy Act (NEPA), the Region IV office of the U.S. Environmental Protection Agency (EPA) has reviewed the subject document. The objective of this study is to restore the ecosystem health of the biotic communities in Everglades National Park (ENP) to the extent practicable through water deliveries from the Central and Southern Florida Flood Control Project. This restoration is based on reestablishing the hydrological conditions prevalent prior to the advent of the multitude of structural modifications built by various development interests in south Florida.

The spatial and temporal distribution of water deliveries to ENP is deemed to be of equal importance to quantity. Moreover, various water quality issues and the impact(s) of nutrient rich water from the Everglades Agricultural Area (EAA) have become more compelling as development exerts a greater influence on ENP and the upgradient Water Conservation Area's (WCA's). These matters must be resolved during the course of EIS and General Design Memorandum (GDM) investigations to determine the best method to achieve project goals.

(1)

After a great deal of study two alternative structural plans for spatial distribution of water delivery and three alternative operational strategies of volume and timing of deliveries were developed for detailed study. Depending on perspective, all of the structural plans and accompanying operational strategies have certain strengths and weaknesses. At this point the Basic Rain-Driven Operational Strategy (BRD) and the Modified Rain-Driven Operational Strategy (MRD) appear to be the most promising operational strategies. EPA supports your determination of the Full Structural Plan as the Recommended Plan. If the endangered species concerns of the U.S. Fish and Wildlife Service (FWS) associated with Snail Kite can be successfully resolved, EPA would recommend implementation of the Basic Rain-Driven Operation Strategy of the Full Structural Plan. Beyond doubt, all of these plans/strategies are intrinsically complicated given the areal extent of the study area

RESPONSES TO

U. S. Environmental Protection Agency — Letter of October 29, 1990

1. For water quality comment, see response to comment #2 in F.A.D.E. letter (page F-4).

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and the magnitude of the processes involved. Because of the complexity inherent in whatever design/operation mode is ultimately chosen, it appears that a final selection must be based on iterative field trials coupled with subsequent inspection of results. EPA agrees with the decision to subject whatever strategy is selected to additional review/comment via the NEPA process.

During this field trial period it is important that detailed monitoring be accomplished. The National Park Service (NPS) has agreed to conduct ecological monitoring to determine the biological response(s) within the Everglades due to changes in water management. In addition to this assessment, monitoring should be expanded to include certain other areas in the hydrological unit, e.g., WCA's No. 3A and 3B and the Big Cypress National Preserve. The expanded scope is necessary to obtain an overview of the biotic and abiotic processes occuring in the basin as opposed to the present focus on the Shark River Slough (SRS) basin of ENP. It is conjectural whether restricting the focus on SRS would yield sufficient definitive conclusions. It is our understanding that a commitment will be sought from the responsible agencies to continue their financial and personnel involvement in the regional effort. EPA is very supportive of this effort.

(2)

EPA urges that the protocol for all monitoring be finalized as soon as possible. Differences of opinion among the principals on a number of fundamental issues have already lessened the possibility that consensus will be reached. This divergence of opinion has reached a point that we are concerned that the Modified Rain-Driven Water Delivery option may be selected by default. This could eventuate irrespective of the monitoring results or literally due to absence of consensus. In an immediately related matter it is doubtful that all parties affected by this plan will be pleased by every element. It may well be that access to some areas will be lessened, some species requirements may not be unequivocally maximized, or some interest groups may have to sacrifice incrementally more than another. If we wait to act until the perfect plan is found, the real possibility exists that nothing will ever be done. It may not be easy to deal with each interest to its satisfaction. However, the overall value of what is being attempted makes the effort worthwhile.

EPA has not been a principal in the development of the proposed rediversion or the subsequent delivery strategies; therefore, there is a reluctance on our part to revisit issues which may have already been addressed during previous interagency coordination. Nonetheless, we wish to assure ourselves that our own agency mandates dealing with the preservation of water quality and wetland protection will not be overlooked or unnecessarily sacrificed relative to the design of structures which will provide sufficient water to ENP. Our observations in this regard are contained in the attached comments.

As a result of our review, we have determined that the major issues about which there is definitive information have been satisfactorily addressed. This determination was facilitated by the cogent presentation

2. for monitoring comment, see response to comment #4 in Dr. Frederick's letter (page F-8).

of the information in the EIS and its supporting documents. This clarity of the text is no small feat given the involved nature of the specific subject matter, the scope of the overall problem, and the multitude of the often conflicting issues involved. It is the current unknowns which we find troubling. At present there are any number of commitments which must be formalized and additional information collected if this project is to realize even a portion of its stated goals. Therefore, although the proposal has very worthwhile objectives, we have a degree of concern about their execution. The results of the planned studies will be necessary and available before a final decision can be made in regard to these unknowns. The final document and a Record of Decision (ROD) will be prepared <u>before</u> these data will be compiled and conclusions drawn therefrom. While this situation is not ideal, we understand and agree with the decision to move forward on construction of the structural measures to effect flow distribution. In fact, in the absence of these measures an operational strategy could never be definitively determined other than by modeling. To deal with this relatively unique set of circumstances and the lack of complete information disclosure now, a rating of EC-2 has been assigned.

Thank you for the opportunity of comment. If we can be of further assistance, Dr. Gerald Miller (FTS 257-3776) will serve as our initial point of contact.

Sincerely yours,

Heinz Mueller

Heinz J. Mueller, Chief
Environmental Policy Section
Federal Activities Branch

cc; attached

Specific Comments

EPA supports the recommendation of ENP relating to the location of the proposed S-345 and S-349 structures along the L-67A canal/levee. It would appear that the proposed spacing of 6,000 feet between the S-345 structures should be greatly increased to spread hydrological flows entering WCA 3B across a wider front, particularily in the northern portion of WCA 3B. Construction of the S-345, S-349 and S-355 structures should minimize direct wetland impacts. (3)

We also agree with another specific recommendation of ENP concerning utilization of East Everglades road fill material in the proposed ENP expansion area for construction of the proposed levee around the 8.5 square mile residential area. Additional wetlands restoration and mitigation credit could be accomplished by this action. (4)

Patterns of residential development/agricultural activities in the East Everglades are confounding water distribution in ENP and, in fact, much of this portion of South Florida. Unless development within this area is either curtailed or managed, it is conjectural whether anything approaching a definitive solution to this conveyance problem will be reached.

Presently this development is concentrated in the 8.5 square mile residential area. The subject proposal recommends that this residential area be leveed off from the remainder of the North East Shark River Slough (NESRS). This would lessen the opportunity for residential flooding when the various water management strategies are initiated. While this levee will protect development from external water, it will also require internal drainage be managed by pumping rainfall and seepage into the L-31N canal.

Currently there are a relatively small number of permanent residences and commercial developments within and around the 8.5 square mile residential area. We suggest that this development will only intensify through time and the problems associated therewith proceed apace. Primary among these problems will be the very real potential for water of reduced quality entering the NESRS through L-31N. Presently the adverse impacts of this water can be lessened via dilution. How long this passive measure of maintaining water quality will remain effective remains to be seen. We recommend that construction of a water retention/treatment basin adjacent to the residential area, to provide treatment of the internal drainage water prior to pumping it to L-31N merits serious consideration in project planning. (5)

The costs both environmental and financial of dealing with an unregulated growth will also escalate. Further thought should be given to relocating this residential development now while the effort would be manageable. This relocation should also be considered for the Tiger Tail Indian encampment which is outside tribal lands on state trustee property. This and the Osceola settlement demonstrate how haphazard development patterns (6)

3. Since coordination of the draft GDM, the S-345's and S-349's were relocated and spread farther apart. This change is reflected in the revised GDM.

4. The suitability of road fill material for this purpose will be assessed during the Feature Design Memoranda (FDM) stage over the next several years.

5. The number of residential settlements in the 8 and 1/2 square mile area is determined by Dade County zoning restrictions. A water retention/treatment basin adjacent to the residential area is not included in the proposed project for the following reasons:

a. The residential area subsoil is composed mainly of limestone rock with high porosity and infiltration rates. This physical characteristic makes retention of water in a retention/treatment basin very difficult unless the basin is lined with some impermeable or semi-permeable membrane or material. During the early rounds of coordination a treatment basin was rejected for this reason and the resulting loss of wetlands. This basin would have been located in the northern portion of the residential area.

b. The proposed canal around the residential area will not be interconnected with any secondary drainage canal or ditch within the residential area. Virtually all water entering the canal will be through groundwater movement from Northeast Shark River Slough; and not from inside the flood mitigation area. Water (groundwater or surface water) will rarely flow from inside the area to the canal.

c. During detail engineering studies, structural and operational measures will be investigated to insure local runoff does not reach the proposed canal. These measures will be discussed in the feature design memorandum for the proposed works in the residential area. For example, a small berm inside the canal right-of-way would prevent surface water from entering the canal. Also, a buffer strip inside the levee would allow maintenance of pristine wetlands vegetation to further protect water quality.

6. Relocation (i.e. buy-out) of the residential area would be considerably more expensive than providing the flood mitigation features: $150 million vs. $43 million. In addition, if residential levees are not included, the absence of flood protection that they provide to the adjacent agricultural areas might necessitate agricultural flood protection features. The environmental costs of the residential flood mitigation plan do not seem to be excessive since EPA recently identified the wetlands habitat that would be lost as "suitable as disposal sites for dredged material" under the AID program. Floodproofing was also less costly than relocating the Tiger Tail camp. This camp is located on uplands so no wetlands loss would be involved in the construction. The Osceola Indian Camp is the responsibility of DOI; the National Park Service requested cost estimates from the Corps to raise the Camp on their behalf. Preventing any problems associated with management of growth in these areas is the responsibility of the State and local governments.

Specific Comments

can become in the absence of effective management. We are sensitive to the rights of native Americans, but in this case happenstance appears to play a larger role in settlement than historic tribal distribution. The fact that some wetland habitat will have to be sacrificed and/or indirectly impacted in flood proofing these sites makes this an immediate concern on our part as opposed to just some abstract interest.

(7) A reconnaissance level survey of the residential area levee and conveyance canal alignments within the study area did not reveal any obvious hazardous toxic wastes. Since this conclusion was apparently reached just on the basis of sight and smell evidence, we suggest that some additional study would be prudent. At the very least some effort should immediately be taken to preclude the area around 121st Street from becoming a dump site for additional debris.

(8) The Full Structural Plan will result in a net wetland loss of approximately 70 more acres than the Minimum Structural Plan. While this is by no means a trivial difference, it is our opinion that the greater flexibility of the former plan and the subsequent restoration of wetlands by water level management throughout the study area more than subsumes this difference. In a related matter, it was suggested that certain functional wetland losses could be offset by creating a shallow littoral zone along the collector and conveyance canals.

(9) We understand that some design modifications may be undertaken to provide fishing access around certain of the structural measures associated with the modified water deliveries. Currently, all the ramifications of these "by-pass" design changes are not immediately apparent. However, we can envision a number of adverse consequences attendant to implementation of this access, e.g., increased wetland losses and water quality problems. Before any additional funds are expended to maintain/increase the subject fishing pressure, it should be determined how this continued access will affect sustainable yield of the resource. Furthermore, all the environmental consequences of this action should be evaluated and compared with the original more restrictive access design.

7. The surveys conducted to date indicate no reason to suspect hazardous toxic waste (HTW) problems. Additional HTW investigations will be conducted during the post-GDM design period. At the Park's request, the Corps will assist in the removal of existing debris that has been illegally dumped in the Park expansion area after the land has been purchased. However, we have no authority to police the illegal dump areas prior to construction. During construction, efforts will be made to prevent unauthorized vehicle access to the dump sites.

8. The idea of littoral zone creation has been abandoned because it is now believed that it would become vegetated with cattail as a result of the superior colonizing ability of that species.

9. See response to comment #1 in F.A.D.E. letter (page F-4). Accommodation of EPA's request to spread the S-349 structures farther apart resulted in an increase from 2 miles to 7 miles in the length of the L-67A Canal that would be inaccessible by boat. The revised plan mitigates for the boat navigation impact by including by-pass channels around the structures. Sustained yield of the fishery is not a factor because it is primarily a catch-and-release sport.

cc:

Mr. Robert S. Chandler, Superintendent
Everglades National Park
P.O. Box 279
Homestead, Florida 33030
ATTN: Bob Johnson

Mr. Bart Bibler
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Vero Beach, Florida 32962-2399

Mr. George Molnar
Dade County Environmental Resources Management
111 N.W. 1st. Street
Suite 1310
Miami, Florida 33128

F.A.D.E.
Fishermen Against the Destruction of the Environment
7120 S.W. 58 Street
Miami, Florida 33143
(305) 666 9478

90 OCT 30 AM 10:39

Tom Cunard, President

October 29th., 1990

VIA FAX - To: 1-904-791-2256

ATTENTION: Mr. Richard Bonner
US Army Corps of Engineers

Mr. Bonner,

With this cover letter you will find a map of Conservation Area 3-A and 3-B. This map shows a new proposal for your water diversion project to restore sheetflow from Area 3-A into Area 3-B. The second map shows an amplification of the detail area for better viewing and clarification.

(1)

You will note that I have included one of your proposed Spillways just south of the Miami River L-67A Canal intersection. This spillway as per our telephone conversation would include a navigation bypass around it as shown in your slide presentations. We must be guaranteed navigation around this structure at times when it would be locked with a minimum of three feet of depth, the width must be determined by your engineers in order to maintain adequate water retention on the Northeast side of the structure. We also must be assured that the locks will remain open when the sheetflow pattern is not operational so we may navigate through the Spillway. Maintenance of the detour around the structure must also be guaranteed.

With the improvement of Structure S-340 so water does not spill around it and the inclusion of the proposed structure south of the Miami River and L-67A Canal, I feel that water can be slowed down, if not stopped down L-67A.

The Six (6) Culverts south of the proposed structure (Which may be amended by you to be more or less) with the inclusion of the Above Water Diversion Dams would allow water to sheetflow from Area 3-A to 3-B in a more normal way throughout the system.

It seems that this system will possibly accomplish everything you are looking for in a system plus it would enhance fishing in that area because of the added structure in the Above the Water Diversion Dams. It would also allow for only one interruption on the L-67A canal, rather than three.

Please model this system and see what happens, I firmly believe that the South Florida Sportsmen will accept it as a valid alternative. I still go on record as objecting to the degrading of Area 3-B until water quality standards are met.

Thank you for your attention to this matter, and if I can be of further assistance please feel free to call on me.

Tom Cunard

Tom Cunard

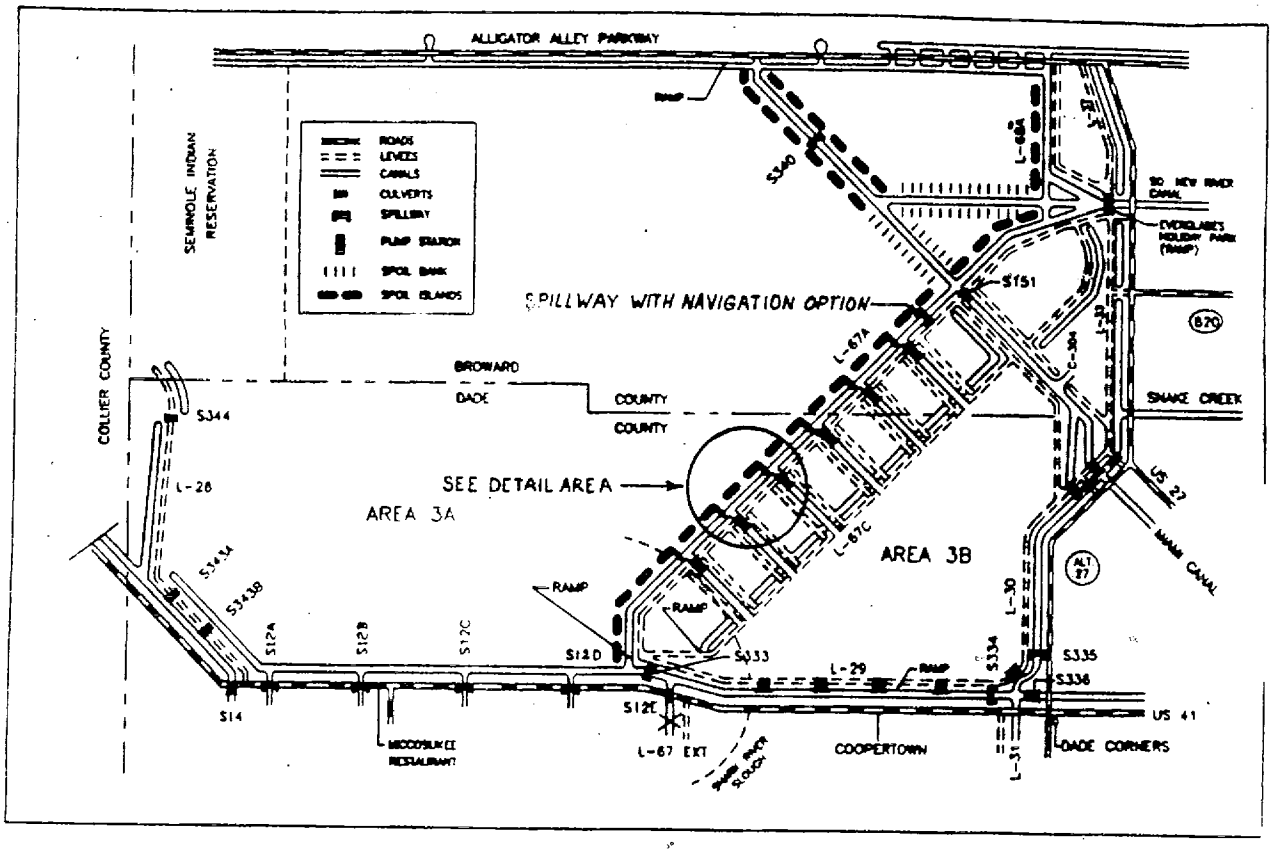
RESPONSES TO

Fishermen Against the Destruction of the Environment (F.A.D.E.)

Letter of October 29, 1990

1. As a result of your input and others the proposed project has been modified to include by-pass channels around the interceptor levees of the structures located in the L-67A Canal. This will permit recreational navigation while allowing the diversion of water needed to meet project purposes. Analysis shows that the by-pass channels would experience depths of less than three feet only under extreme droughts. Current design calls for the channels bottom to be at elevation + 4.0 feet, NGVD. Your proposed plan was one of the several considered. It was not recommended because the channel with the suggested arrangement would be unsafe, or if made wider it would not meet project purposes.

Attn: [illegible]



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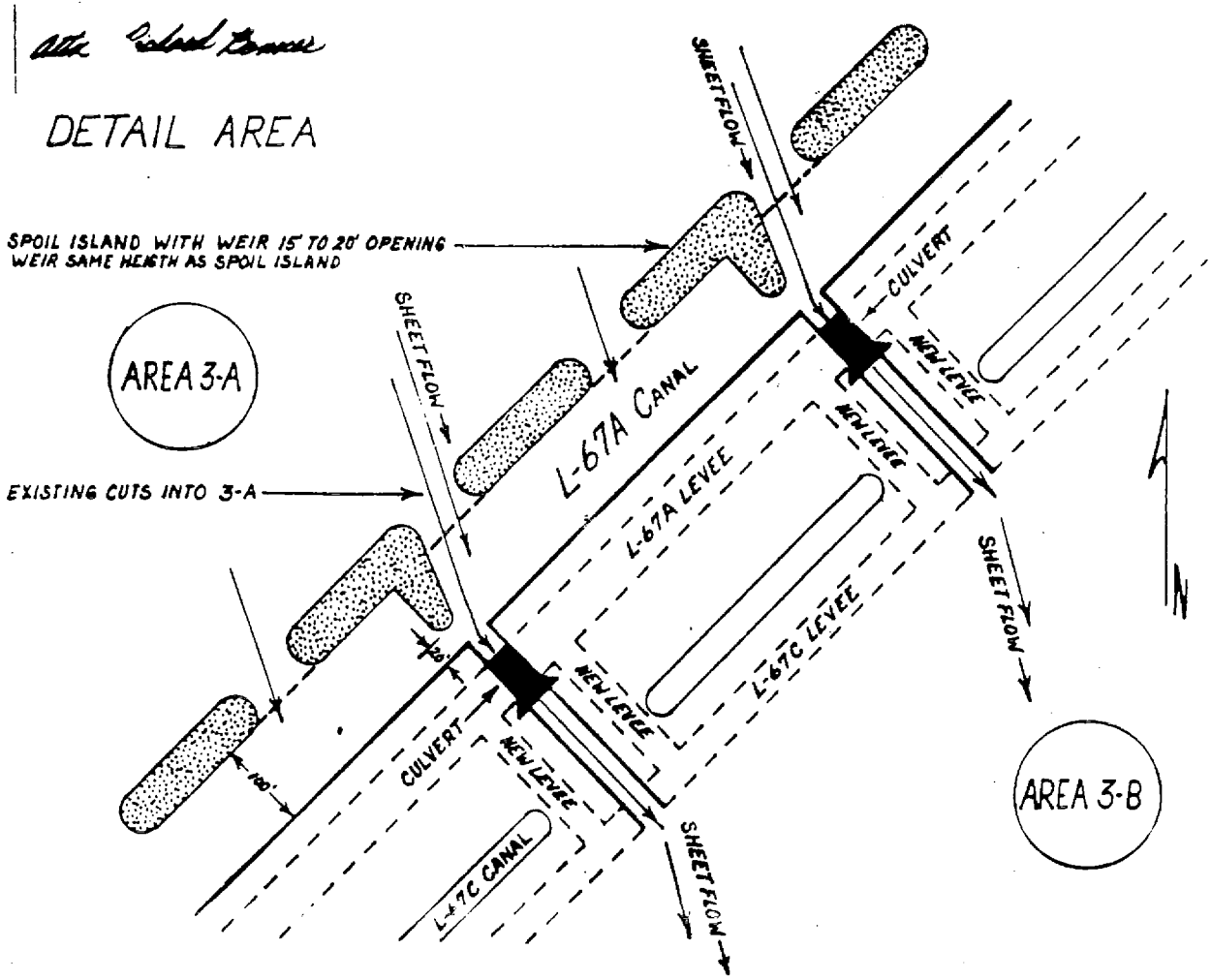
DETAIL AREA



F-52

G&A GHIOTO & ASSOCIATES
WATER RESOURCES AND CIVIL ENGINEERING

RODNEY D. GHIOTO, P.E.
OWNER

October 29, 1990

Col Bruce A. Malson
District Engineer
U.S. Army Corps of Engineers
Jacksonville District
P.O. Box 4970
Jacksonville, FL 32232-0019

Subject: GDM on Modified Water Deliveries to ENP and Draft EIS

Dear Colonel Malson:

We are transmitting the attached comments on the subject document on behalf of the Florida Lime and Avocado Administrative Committees. We also request that these comments be made a part of the record.

As is evident in our comments, the FLAAC has substantial concerns regarding this matter. Therefore, we request that you directly address those concerns prior to finalization of the documents. We will be happy to discuss this matter with you and your staff at any time.

Very truly yours,
GHIOTO & ASSOCIATES

Rodney D. Ghioto, P.E.
Owner

RDG/lg
cc: Jon Moulding, USACOE
Louis Hornung, USACOE
James Humble, FLAAC

8750 MAJOR BOULEVARD SUITE 370 • ORLANDO FLORIDA 32819 • PHONE (407) 345 6224

Comments on

General Design Memorandum on
Modified Water Deliveries to ENP
and Draft Envrironmental Impact Statement

Prepared for

Florida Lime and Avocado Committees

by

GHIOTO & ASSOCIATES

Water Resources and Civil Engineering

October 29, 1990

INTRODUCTION

This document provides technical commentary on the GDM and the DEIS on behalf of the Trustees of the Florida Lime and Avocado Administrative Committees. After careful technical review, we have concluded that it is highly likely that the proposed plan will not function as intended with regard to flood control. It will likely fail in safeguarding areas both east and west of L-31N, as well as the C-111 Basin, from increased flood risk. Deficiencies in the proposed plan are considered too serious for refinement at the Final Design Memorandum (FDM) stage and warrant a revision at the GDM stage. We feel that revisions which will be necessary are required at the planning level and will need to be subjected to the same level of review that this document is receiving. Deficiencies in the computer modeling are serious enough to nullify all of the conclusions regarding flood protection in the East Everglades, the L-31N area, the L-31 area and the C-111 Basin.

It is our opinion that a new levee, parallel to and west of the L-31N levee, is the only structural option that has the potential to provide needed safeguards. This levee would tie into Tamiami Trail on the north and the proposed residential (1) levee on the south. It is further proposed that two or more pump stations be located strategically along this levee with discharge of seepage flow from the L-31N canal back to the west into NESRS.

In addition, it is proposed that the residential levee system be expanded to include adjacent agricultural areas to the south to mitigate flood threats created by the IAP (LOOP) as (2) well as the proposed plan. Discharges from the protected residential and agricultural areas should be directed west to NESRS instead of to the L-31N canal. Implementation of these proposals is, in our opinion, the only way that protection of agricultural areas both east and west of L-31N can be insured.

(3) The seepage control levee that was previously proposed for Conservation Area 3B should also be included in the plan. It is vital for the reduction of seepage to L-31N.

RESPONSES TO

Ghioto & Associates letter of October 29, 1990

1. The addition of a seepage levee west of, and parallel to L-31N was considered in the early phases of this project. However, this plan was objected to by a number of resource agencies because of the resulting loss of wetlands. The pumpage of excess water from two or more pump stations would be inconsistent with the general project objective of restoring natural hydrologic condition.

2. Output data obtained using the South Florida Water Management Model show the project would not adversely affect adjacent agricultural areas. However, additional modelling is included in future studies regarding the operating criteria of the project. Future analysis will include adjacent agricultural areas to insure no adverse impacts would result from implementing the project.

3. Adequate capacity at pump station S-356 will be provided to convey excess seepage from the southeast corner of WCA No. 3B in lieu of a seepage levee.

TECHNICAL COMMENTS ON THE GDM

Page 13. Paragraph 17. BASE CONDITION

Although not mentioned in this section, the "Base Condition" includes the Lake Okeechobee Operating Permit (LOOP), previously known as the Interim Action Plan (IAP). This mode of operation consists of the southward pumping of excess runoff from the EAA to the WCA's. In fact, as stated in Paragraph 43 (Basis for Objective) on pages 23 and 24, the additional input to ENP was one of the primary concerns that caused this GDM to be undertaken.

It is our position that the inclusion of the LOOP in the base condition has a tendency to mask increased flood risks that have already been incurred in the East Everglades area (See our comments of January 1987 in Appendix A). These increased flood risks are the result of operational changes to the existing project that have altered its performance from the original project design. Previous estimates by the SFWMD place the increased flows in the range of 200,000 to 400,000 acre-feet per year depending upon rainfall in the EAA area.

By including the LOOP in the base condition, the Corps is stating that any resulting damages (increased flood risk) incurred by residents and agriculture in the East Everglades are acceptable as an existing condition and do not require mitigation. This is diametrically opposed to the undertaking of this GDM to mitigate those risks for Everglades National Park. Flood mitigation for the residential area (as stated) is to offset changes that would take place with the plan, over and above those caused by the LOOP. The DEIS states that there will be no adverse impacts to agriculture and therefore no mitigation is necessary. Therefore, any adverse impacts to agriculture arising from the LOOP that should require mitigation are totally ignored. In fact, the document states that increased stages at the south end of L-67 Ext., resulting largely from regulatory releases, are currently causing problems for East Everglades agriculture. (4)

In this section and in other locations within the document, historic annual flows through the S-12 structures to the chimney of the park are cited. It is technically incorrect to (5)

4. Two model simulations were performed for the base condition. One model did not include the IAP, the other one did. Output of this modelling showed no impacts with the IAP. Results of this modelling effort were presented to you at a recent meeting.

5. When the Experimental Program for modified water deliveries to ENP was authorized in November 1983, post-IAP water control regulations were in effect. The IAP was established in 1979 as an interim measure. In response to concerns and requirements by the Florida Department of Environmental Regulation regarding eutrophication of Lake Okeechobee, the South Florida Water Management District implemented the IAP in early 1983. This plan called for pumping maximum allowable volumes of water from the Everglades Agricultural Area to the WCA's, before pumping into Lake Okeechobee takes place. The IAP was adopted as the long-term plan in 1986, and is now referred to as the Lake Okeechobee Operating Permit (LOOP). See response above. The Base Condition is defined as the condition that is currently in existence, including any changes that are reasonably expected to be made in the future without the project. At the time the Base Conditions for this project was defined, the Interim Action Plan had been in place for about 5 years and it appeared that it would be the permanently adopted operating plan. (In fact, shortly thereafter, it was adopted as the Lake Okeechobee Operating Plan (LOOP). This plan was implemented by the SFWMD within the existing operating criteria prescribed by the Corps. In response to concerns expressed early in the project, the impacts of the LOOP were modeled. The results showed no significant impact on flood risk related to the LOOP.

cite average annual flows over periods of record that do not distinguish pre-IAP (1979) versus post-IAP conditions. The document should make this distinction and evaluate induced changes since 1979 as impacts to adjacent lands. In addition, all increased flood risks (damages) attributable to the IAP (LOOP) should be mitigated as well as those induced by the proposed plan.

Page 46. Paragraph 54.c.

"Subsequent studies indicated that impacts in the agricultural area do not require mitigation. Therefore, Plan B, which addresses both the residential and agricultural areas, was dropped from further consideration."

The above quotation is the only justification included in the GDM for not protecting agriculture in the East Everglades. If (6) the Corps comes to the same conclusion after revising the models and re-evaluating the proposed facilities, we would like to have more detail than was provided in this draft.

The previous discussion regarding IAP impacts applies to this paragraph as well. There are potential hidden damages to agriculture that are being overlooked by the GDM.

Page 48. Paragraph 57. <u>Agricultural Area Monitoring</u>

Although PL 100-229 provides for monitoring and evaluation of impacts on agricultural areas within 18 months of project completion, it should be emphasized that this monitoring and evaluation should continue until such time that statistically (7) valid conclusions can be reached. In addition, monitoring of potential agricultural impacts should be conducted with each change in operational methods that is made during the "iterative testing process". The benchmark condition for judging impacts should be the pre-IAP condition (prior to 1979).

Because rainfall volumes along with the occurrence of floods is stochastic, it is highly unlikely that any 18-month period will yield conclusive evidence of adverse impacts of the project. Therefore, regardless of the language in PL 100-229,

6. The authorizing legislation (PL 101-229) states that mitigation shall be provided for increased flooding that would result by implementing the proposed project. When the initial array of structural mitigation plans was developed, the extent of potential flood impacts that required mitigation was uncertain. Plan A was formulated to provide minimal flood mitigation for the residential area. Plan B added the agricultural area lying to the south. Modeling results showed that Plan A mitigated flooding for all frequencies well south of the residential area, thus making separate protection for the agricultural area unnecessary. Therefore, Plan B, which addresses both the residential and agricultural areas, was not necessary and dropped from further consideration. Additional analyses were described in the economic appendix.

7. Section 104(d) of the Everglades National Park Protection and Expansion Act (PL 101-229), does not include any limitations on the duration of the "Periodic Review". In conducting the review "the Secretary of the Army shall consult with all affected parties". Regarding the IAP, this issue was addressed in previous paragraphs.

the Corps is obligated to ensure that its project and its current, as well as future, operation does not jeopardize adjacent lands.

Pages 53-55. Paragraphs 64-66. Incremental Impacts

These paragraphs discuss incremental impacts that would occur during the three phases of project construction. However, on page 79 it is recommended that the project not be phased. The Corps should be clear on how implementation is to proceed so that the affected public and private interests know what to expect. (8)

Page 53. Paragraph 64. First Increment

As a result of the first increment of construction, there would be increased risk to agricultural areas in the East Everglades due to the mounding effect at the southern end of the L-67 Ext. Levee. (9)

If a flood were to occur during the construction period, agriculture in the area could be virtually eliminated. These risks are simply unacceptable. In effect, the current testing in the area falls into this same category.

The conclusion that the mounding effect results, to a large degree, from regulatory releases into the chimney of the park is well taken. In fact, the frequency and rate of these regulatory releases are exacerbated by the Lake Okeechobee Operating Permit (LOOP). This operational alteration of the project has not only been allowed by the Corps, but also totally ignored in the development of the GDM. In fact, it has been treated as an acceptable basis for judging performance.

The conclusion that the mounding would constitute a negative impact on agriculture must therefore be extended to the LOOP's effects on the area as well as that of the iterative testing that has been conducted over the past several years and continues today. It is our opinion that the flood risks associated with both of these activities are contrary to the original design of the project and should be part of the

8. The "Environmental Incremental Analysis" is presented as a tool for analyzing environmental benefits that the project would achieve as components of the project are incrementally added. This section is not intended to address the planned construction sequence. The actual construction sequence is reflected in figure 23 of the GDM.

9. Under current design and construction schedules the last order of work would be the removal of L-67 Extension. This would avoid potential impacts to the East Everglades residential area and adjacent agricultural lands.

mitigation for the proposed project. This mitigation is not included in the proposed project because the LOOP is included in the base condition which is the basis for all impact assessments in the GDM and DEIS.

Page 56. Paragraph 67. Description
Discussion of Iterative Testing Process

The Iterative Process is discussed in some degree of detail. However, there is no formalized methodology for determining what constitutes an operational alternative as well as the time it will take to determine if an alternative is successful or not. There is no statement as to who (which agency) will be the judge in these matters. (10)

Without the formalized structure discussed above, there is a high probability that there will be significant pressure, by persons or agencies, to test "pet" alternatives. In addition, it is likely that such pressures will result in any given alternative to be prematurely discarded or terminated so that its merits can not be fully evaluated. Previous discussions with participating agencies have revealed that it could take many years of data collection to properly evaluate delivery mechanisms.

Although the GDM discusses the necessity of modifications to the EIS, the use of EA's and FONSI's, there should be a statement directly related to the monitoring and evaluation of potential damages to agriculture for each alternative before, during and after the testing of each alternative. Otherwise, as has happened in the past, there is a risk that these potential impacts will be simply dismissed without the benefit of formalized treatment. In addition, there should be a statement that any such damages will be corrected and/or mitigated prior to testing of any alternative. These comments are directed to potential damages both east and west of L-31N as well as within the C-111 Basin.

10. Before testing any alternative, extensive modelling would be conducted to assess its merits and shortcomings. The recommended plan should provide operational flexibility, and still meet the objective of restoring natural hydrologic conditions of ENP. As stated in the GDM, the iterative process would include preparation of a supplement to the EIS or an Environmental Assessment (EA). The Corps of Engineers will coordinate all alternatives proposed.

APPENDIX D HYDROLOGIC ANALYSIS OF EAST EVERGLADES

Page D-30. Paragraph 32. Level of Protection

As stated here and elsewhere, the proposed levee design has been lowered to allow it to be overtopped by wave action during severe storms. This is justified by the statement that, when overtopping occurs, overland flows will not cause additional damage. However, there is no assessment of the possibility of levee failure during such events. If the levee fails, overland flow will be much more severe and the condition will last for an extended period of time. The Corps should address this possibility because overtopping wave conditions can have serious implications with regard to potential failure induced by erosion of the levee crown. (11)

Page D-37. Paragraph 40. Pumpage Volumes

This paragraph discusses the impacts on S-331 pumping by comparing base conditions to the proposed plan. Average monthly pumped volumes are provided in Table D-25 (reproduced below for ease of reference). (12)

TABLE D-25

S-331 DISCHARGES* FOR BASE CONDITION AND RECOMMENDED RAIN-DRIVEN PLAN

	Base Conditions (ac.ft.)	Recommended Rain-Driven Plan (ac.ft.)
Jan	7,077	9,857
Feb	7,466	8,129
Mar	8,924	7,788
Apr	5,016	4,990
May	4,495	4,434
Jun	5,890	7,414
Jul	5,668	8,479
Aug	4,799	7,070
Sep	5,554	9,283
Oct	6,175	10,242
Nov	6,808	11,518
Dec	5,463	8,989
Total	73,335	98,196

* 1969-75 Average

11. The purpose of the proposed protection system in the residential area is to mitigate for increased flood risks due to the project. Overtopping of levees during hurricane wind setup will not worsen flooding inside the residential area. Under these conditions the area would be already flooded, since the system does not enclose the residential area. A low level dike would not create a flood wave that could worsen conditions in the area. Even without the project, periodic flooding in the residential area occurs under natural conditions.

12. Besides water supply releases, current operating criteria for S-331 include releases of flood waters based on available capacity of the downstream canals. Since this criterion is difficult to simulate, the 2x2 model used the S-331 pump station for water supply purposes only. However, in the 1x1 model this was not the case. Future modelling with the 1x1 will include the same criterion used in the 2x2 model. The flood mitigation features have been designed with adequate capacity to prevent adverse flood impacts without reliance on southward discharges to C-111.

As stated in paragraph 40: "Even with a 900 cfs backpump at the north end of L-31N a sizeable increase in S-331 pumpage occurs".

From discussions with Corps Staff, it has been determined that the model included S-331 as a 50-foot wide weir at elevation 5.0 feet (NGVD) during the wet season. Therefore the average monthly volumes shown above include flood flow transfers to (13) the C-111 basin as well as water supply flows required for minimum deliveries to the Park. This was included for both the base condition and the recommended plan. On the following page, it is further concluded that: "The concentrating of water along L-31N results in a slight increase in flood frequencies in the C-111 area".

There are a number of problems associated with this part of the appendix. As stated on several occasions, it is the Corps' intent that the plan not move water south into the C-111 basin during flood control operating periods (defined as periods when water levels are above optimum). Discussions with staff have resulted in the realization that the model analyses are in error and will have to be revisited.

In our opinion, this problem will require more than a visit because it has potential ramifications on the viability of the proposed plan. Because the use of S-331 was included in the (14) modeling, it effectively took much of the load off of the proposed 900 cfs pump station at the north end of L-31N. The net result was the conclusion (in error) that stages in L-31N would be acceptable. In our opinion, when the model is fixed and rerun, it will be shown that a pump station at the north end of L-31N will not be able to maintain reasonable canal stages. As a result, there would be increases in groundwater elevations both east and west of L-31N from Tamiami Trail to the S-331 Pump Station affecting large agricultural areas with both tree crops and winter vegetables. In addition, tailwater stages and potential back seepage to the residential area could inhibit the ability of the proposed residential area flood control plan to function properly.

(15) The above scenario is further exacerbated by the seepage potential from the NESRS to the L-31N canal. It is our

13. The operating criteria used for S-331 under the 1x1 and 2x2 model were discussed in the previous paragraph. With the project, S-331 would not be used to relieve excess seepage water resulting from its implementation. However, this problem may be alleviated by assessing the impact of new or future structures in the project area. For example, culvert structure G-211 and the proposed West Dade County Wellfield could reduce the impact of the proposed project in the East Everglades. These new project features would be modelled in the future.

14. See response #12. The design of the flood mitigation system will not rely on C-111 to "take much of the load off." Results from the computer modeling show that during peak pumping times, the canal stage in L-31(N) is higher than in the residential area. Therefore, backseepage is already occurring and is being handled by the proposed pumping plan.

15. In calculating the seepage into L-31(N) south of Tamiami Trail, it is assumed that the layer of silt and organic marl overlying the highly permeable limestone retards seepage into the canal during flood stages. If this assumption is correct, the modeled seepage rate and resulting water elevations in L-31(N) would be accurate. If this assumption is not correct, seepage into L-31(N) would increase dramatically. Modeling done for this condition shows that an additional seepage levee, as originally presented, would do little to reduce the seepage flow into L-31(N). For this scenario, it would be better to widen the existing L-31(N) levee. This would provide a longer seepage path and would reduce the flow into the canal. During the FDM design phase, the continuity and permeability of the organic upper layer will be investigated. The investigation will include percolation tests, pump tests, and a possible canal drawdown test in L-31(N). The results of these investigations will be included in the computer models and seepage analysis. If the upper layer of silt and marl is not considered, modeled seepage rates south of Tamiami Trail increase considerably. Results from the Corps' analysis for this scenario are approximately the same as those measured by the USGS field tests (the USGS field tests only measured seepage through the very permeable limestone aquifer). Again, it is felt that the organic layer overlying the limestone will be an effective barrier against seepage during flood stages (see previous paragraph).

understanding that the Corps will be conducting further pump tests in that area to refine the modeling of seepage. However, direct measurements in that area by the USGS place seepage rates in the neighborhood of 630 cfs per mile per foot of head, far in excess of those used in the modeling to date.

In our opinion, seepage to the canal will be uncontrollable by use of a pump station (of any size) at the north end of the canal. The fact that the highest seepage flows will occur between the north and south pump stations causes even greater concern over recirculation at the northern facility with little efficiency in removal of pumpage to the canal from the residential area.

If the proposed plan was constructed and operated as the Corps states, both the Corps and the SFWMD will be put into a posture of having to use S-331 to move flood waters south into the already stressed C-111 Basin. This is, in our opinion, an inevitable outcome given the commitment to residential flood protection that must be met by congressional mandate.

Increases in flood frequency for the C-111 basin are higher than indicated by the numbers provided. The fact that the model error exists for both the base condition and the proposed plan is an indication that increased damage potential is not merely related to the difference between the two cases, but to much larger volumes during the wet season (closer to the absolute value of the recommended plan numbers). In addition, monthly averages are not an indication of flood severity from storms that occur over a period of a few days. The latter can be much greater when they are not averaged with periods of non flooding conditions.

Page D-37. Paragraph 41. <u>Inundation Frequencies</u>

(16) Results presented for inundation frequencies, as well as the S-331 pumpages contained in Table D-25, are for the period of 1969-1975 only, instead of the entire simulation. It is stated that this was done because: "...there was little difference between the first and second 7 years of the test period". If there was little difference, then the entire period should have been reported so that the statistical validity of the results is further supported.

16. The main purpose of pumpage volumes presented in Figures D-28, D-29, and D-30 was to compare other alternatives with the base condition. There was little difference in total rainfall between the 1969-75 and 1976-82 periods. The 1969-75 period was chosen since it contained the largest flood and the most severe drought. The operating criteria used for pumping station S-331 under the 1x1 and 2x2 model were discussed in a previous paragraph.

In fact, because of the modeling errors discussed above, all of the conclusions regarding inundation frequencies are incorrect, especially in the L-31N, L-31 and C-111 canal areas. However, there are a few observations that should be made. Figure D-30 provides differences in percent of time flooded for the 1x1 model area. Even with moderating effects of S-331 flows to the south, there is an increase in flooding east of L-31N near Tamiami Trail. However, there is no discussion (anywhere in the documents) related to mitigation of those differential damages. The same is true for increases shown in the C-111 Basin. Was it assumed that these increased damages are acceptable? Do they not require mitigation?

It should also be pointed out that flood damages to agriculture are related to root zone flooding and not just to surface flooding. Therefore the affected areas would be even larger than shown in that Figure.

Grossman Road Borrow Canal

To our knowledge, this canal is still present and functional. It is connected between grid 29,49 and grid 24,49 on the 1x1 model. In looking at Figure D-30, it can be seen that it connects areas of increased flooding to areas of decreased flooding. Because this canal possesses a rather large cross section, it can be expected to intercept surface and ground water and convey considerable flow between NESRS and East Everglades agricultural areas. (17)

There is no mention of this canal in the GDM with regard to its inclusion in the model or any necessary modifications to avoid transfer of flow to the south. It is requested that it be included in further simulations and evaluated in regard to further project modifications.

17. Additional evaluation of the potential impacts of removal of this canal will be conducted.

APPENDIX F - BASE CONDITION

Page F-17. Paragraph 8.c. S-331

(18) The equation used for computation, as written in the report, is incorrect. It should be:

Q(L-31N OUTFLOW) = 7.22*GWDTH*((DEPTH - CREST)**1.5)

If modeling were to be done using the equation contained in the report, computed flows would be several times the magnitude produced by the above equation.

The current "optimum water level" for L-31N is at elevation 5.0 feet, NGVD. This is the weir elevation chosen to activate flow through S-331 during non-delivery periods.

For the past several years we have voiced concern over the potential transfer of flood problems from the L-31N basin to the C-111 Basin (See our January 1987 comments in Appendix A). The response from the Corps was that there would be no connection to the C-111 Basin during non-water delivery (wet season) periods. The above referenced discussion indicates that, while this may have been the Corps' intent, the modeling as well as evaluation of results has been based on the use of S-331 as a flood regulation device.

18. This was a typing error that has now been corrected. The formula as used in the model runs was correct

HYDROLOGIC ASSOCIATES U.S.A., INC.
14707 South Dixie Highway, Penthouse #403, Miami, Florida 33176
Phone: (305) 252-7118 • Fax: (305) 254-0874

October 29, 1990

Colonel Bruce A. Malson, P.E., District Engineer
U.S. Army Corps of Engineers
400 West Bay Street
P.O. Box 4970
Jacksonville, Florida 32232

RE: General Design Memorandum for Modified Water Deliveries to Everglades National Park, Florida

Dear Colonel Malson,

Attached are technical review comments on the subject GDM made in behalf of the South Dade Land Corporation by Hydrologic Associates U.S.A., Inc. Our primary concern is increased susceptibility to flooding after the GDM is implemented. It is felt that without adequate safeguards, the proposed structural and operational changes will greatly increase flood risk to South Dade Agriculture over and above the risk we face today.

Our comments are directed at these increased flood risks and include the following categories:

(1) 1. Discrepancies in base water level conditions in the Taylor Slough basin from published data.

(2) 2. Lack of consideration of recently collected seepage and aquifer test data in the vicinity of L-31N canal.

(3) and 3. Increased flood risk to South Dade County by implementation of the MRD Plan as opposed to the BRD Plan.

We urge you to consider these comments and modify the GDM facilities in such a way as to provide adequate flood protection for the L-31 and C-111 basin and prevent the dumping of excess stormwater on South Dade County through the use of pump station S-331.

cc: James Humble - SDLC
Lewis Hornung - COE
Dr. Jon Moulding - COE
Harold W. Turman II
Rod Ghioto, P.E.

Sincerely,

Bradley G. Waller
Principal Hydrologist

cm

RESPONSES TO

Hydrologic Associates U.S.A, Inc. Letter of October 29, 1990

1. Data used in the model were collected by the Corps, the SFWMD and the USGS. These data were used for calibration of the model.

2. The computer model was developed before these data were published. As new data becomes available the model will be updated to better reflect actual conditions. Estimates of seepage made outside the hydrologic model have taken all available data into consideration. The seepage issue is discussed in the Technical Review Comments section.

3. The proposed recommended plan involves the construction of project features that would allow the greatest flexibility in restoring the everglades. A better operating criteria for the structures would be developed through an iterative testing procedure. The testing procedure will consider flood control, water supply, and water quality. However, the GDM recommends use of the MRD only if the parties involved (the Corps, the ENP, SFWMD, and others) cannot agree on an improved operating design.

HYDROLOGIC ASSOCIA .C.
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Technical Review Comments

of the

Corps of Engineers General Design Memorandum

for

Modified Water Deliveries to Everglades National Park

Prepared by

Hydrologic Associates U.S.A., Inc.
14707 South Dixie Highway, Suite 403
Miami, Florida 33176

for

The South Dade Land Corporation

Miami, Florida
October 31, 1990

HYDROLOGIC ASSOCIAT

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Technical Review of Corps of Engineers General Design Memorandum for Modified Water Deliveries to Everglades National Park, Florida.

The following is a summary of technical questions are posed regarding the COE GDM dated July 1990 and review comments on apparent technical discrepancies in the GDM.

1. Taylor Slough Water Levels and Land Elevations

Discrepancies are noted in tables 9, 10, and 11 in the main text of the GDM which report median and maximum water levels, and inundation periods. These tables give the base condition and changes relative to the base condition for modeled rain-driven water delivery alternatives. The problem lies with the water levels in the Taylor Slough basin which are used to determine the base condition for the model. The discrepancies are noted in the following table.

	Median Stage		Max. Stage		Inundation	
	Reported	Actual 1.	Reported	Actual	Reported	Actual**
NP 206	5.8	5.0	7.2	6.99*	270	150
TSHO	4.8	2.7	6.1	5.34 *	45	180
TSRP	5.4	2.2	6.8	E5.2	8	200

1. From the files of the U.S. Geological Survey and Stage/duration analyses

* August 20, 1981

** Estimated from land surface datum and stage/duration analysis

The discrepancy for NP 206 may lie in the fact that it was operated in 1975 and 76 water years with an arbitrary datum approximately 5 feet higher than the mean sea level datum. Stage duration curves for Taylor Slough near

4. Data used in the model was collected by the Corps, the SFWMD and the USGS. The Base Condition is a result of model runs without any modifications to the C&SF Project. Although the stages are higher than the published data, the Base Condition still remains the benchmark from which the other plans are compared.

Homestead are included for your use. These curves were generated from the published files of the U.S. Geological Survey WRD. Also please note that Taylor Slough at Royal Palm is downgradient of TSHO.

Land surface datums at the stations should be as follows:

NP 206	-	5.7 feet
TSHO	-	2.6 feet
TSRP	-	2.3 feet

The effect of these discrepancies is that the model is using water levels in the base condition that are much higher than actually occurred. The rain driven models are trying to match these water levels as closely as possible. Therefore more water is being routed to South Dade in the model to match higher water levels than actually occurred historically. Theoretically this could raise water levels and increase flood risk in South Dade by use of non representative data. It is suggested that these base conditions for Taylor Slough that area used in the model be checked against the USGS data to verify the correct median and maximum values. Periods of inundation should also change as a result of this data base change. Data from the USGS for Taylor Slough near Homestead and Taylor Slough near Royal Palm are attached for your use.

2. Effect of increased seepage into L-31 N Canal

(5) There is little doubt that seepage into the L-31 N Canal between the Tamiami Trail (S-334) and S-331 will increase

5. Restoration of the Everglades would require increase duration of hydroperiods. This can only be accomplished by increasing water levels in the area. Since Station NE-2 is located below Tamiami Trail, water stages near the gage would also be considerably higher. However, considering the topography of the area, overland flow would drain mostly towards the southern end of the slough. In calculating the seepage into L-31(N) south of Tamiami Trail, it is assumed that the layer of silt and organic marl overlying the highly permeable limestone retards seepage into the canal during flood stages. If this assumption is correct, the modeled seepage rate and resulting water elevations in L-31(N) would be accurate. If this assumption is not correct, seepage into L-31(N) would increase dramatically. Modeling done for this condition shows that an additional seepage levee, as originally presented, would do little to reduce the seepage flow into L-31(N). For this scenario, it would be better to widen the existing L-31(N) levee. This would provide a longer seepage path and would reduce the flow into the canal. During the FDM design phase, the continuity and permeability of the organic upper layer will be investigated. The investigation will include percolation tests, pump tests, and a possible canal drawdown test in L-31(N). The results of these investigations will be included in the computer models and seepage analysis.

greatly with the adoption of any of the rain driven plans. Proposed water levels in the NESRS will be raised over 1 ft throughout the entire area. This action would raise the water levels based on modeling efforts at station NE #2 to the following:

Water level	Percentile
8.2	10
7.7	20
6.9	50
6.4	80
6.0	90

Water would be above land surface (5.6 feet) approximately 95 percent of the time. These levels represent an approximate 1 foot increase over current levels.

Seepage rates into the L-31 N canal have recently been calculated by the U S Geological Survey and the Corps of Engineers. Near the Tamiami Trail, the USGS calculated the rate to be 630 CFS /mile/ft. of head. Closer to the 8.5 mi^2 residential area the Corps calculated seepage rates to range from 1275 to 2000 CFS/mile/ft. of head. Given that the optimum stage in L-31 N is proposed to be 5.5 feet at S-334, seepage rates will increase into the L-31 N Canal. Something has to be done to this additional volume of seepage water to prevent increased flooding potential to South Dade agriculture. The continued reliance on pump station S-331 for flood protection must be eliminated to prevent additional increased flood risk in the L-31/C-111 basin.

The proposed plan is to pump this excess seepage northward (against a gradient) into the Tamiami Canal at a proposed station S-356 with a capacity of 900 to 1340 CFS depending on the section in the GDM. Either one of these capacities is too low for the intended purpose of flood control. Therefore, it is recommended that the COE consider resizing this pump station to adequately remove excess seepage water and prevent the use of S-331 to remove flood waters and increase flooding potential in the L-31 N/ L-31 W / and C-111 basin. Consideration should also be given to a series of pumps if one pump at S-356 is too costly or inefficient. It is also suggested that a double seepage levee be constructed in the northern section of L-31 N to retard the increased seepage from NESRS. An additional seepage levee should also be constructed between S-334 and S-335 to retard seepage from WCA 3B. Any additional seepage from WCA 3B would pose an additional burden on proposed pump station S-356. These seepage levees were previously proposed but have been deleted from the final document.

(6)

The consequences of increased water levels in L-31 N and an inadequate flood control pump station are obvious to the South Dade Agricultural community. If the system does not work, then S-331 will be used in a flood control mode and the risk of additional flooding is again real and South Dade County is no better off than during the 1988 floods.

(7)

6. The issue of increased seepage along L-31N was addressed with the addition of pump station S-356. This pump station would mitigate for additional seepage derived from the project. Maximum water deliveries to NESRS are expected between 1,800-2,200 cfs during a storm similar to the 1969 event. These flows would occur when the entire area is already flooded. Due to natural ground topography, water delivered to the NESRS area would drain mostly towards the southern end of the slough. This would result in seepage rates significantly smaller than those delivery rates above. Data published by the USGS, agrees with past tests done by the Corps since the 1950's. However, these data are for a very permeable limestone aquifer which does not include any surficial conditions in the area.

7. In addition to water supply releases, the current operating criteria for S-331 includes flood water releases on a secondary basis based on available capacity of the downstream canals. Under the same criteria S-333 would not discharge when the downstream stage of S-331 exceeds a maximum permissible level. These criteria were not simulated in the 2x2 model, consequently, the S-331 pump station was used for water supply purposes only. In the 1x1 model this was not the case. Future modelling will include the same criteria for both models. Since the proposed features in the residential area are for mitigation only, occasional flooding will occur in the area south of S-331. These events would be neither prevented nor aggravated by the project and would occur naturally regardless of whether the proposed mitigating features are built or not. After the project is built, any event similar to the 1988 flood should cause a like flooding condition in the South Dade County area.

In a further note along these lines, I think the COE should present technical information showing the E-W transitional water levels between the NESRS to L-31 N and to the West Wellfield area under different hydrologic conditions. This information is available and would greatly benefit any impact analysis in this area. The COE should explain the effect of transitional water levels (hydrologic buffers) to be expected and the effect of the canal and wellfield under various hydrologic conditions.

(8) In order to better design the pumps and levee systems, the COE should reconsider the size of the pumps and design of the levees based on transmissivity values for the L-31 N canal area. The USGS has reported values of 1.7 million ft^2 /day (Fish and Stewart) and 1.8 million ft^2 / day (Chin, 1990) for two separate tests in the vicinity of the Tamiami Canal. In Appendix G of the GDM, transmissivity values calculated by the Corps were reported to range from 500,000 to 3.5 million ft^2 /day. These numbers are large, but not unusual for South Dade County. Because of the magnitude of T-values, reconsideration of the pump station capacities has to be made.

3. Effects of Modified Rain Driven Plan (MRD)

(9) The COE has selected the MRD plan for implementation of the GDM. The MRD calls for an environmental floor of 9.0 MSL above S-12D when water is available. This water requirement, estimated at 60,000 to 100,000 acre feet per year would come

8. More investigations will be conducted during the FDM to address the S-356 pumping station issue. Transmissivities used for design in the study area were selected using the most accurate and current information available. Every effort was made to collect as much information in the study area as possible. The transmissivity of 1.7×10^6 ft^2/day, reported by Fish and Stewart, was obtained from the USGS during the GDM investigation and was incorporated into the model. The 1.8×10^6 ft^2/day transmissivity, reported by Chin, was not available during the GDM investigation (the referenced report has not yet been published). However, the value is very similar to the transmissivities reported by Appel, which were used in the analysis. Additionally, the seepage rates into L-31(N) reported by Chin closely agree with the Corps' analysis of the same scenario. Appendix G describes in detail the tests and test results that were considered in the design. South of Tamiami Trail, the silt and organic marl overlying the aquifer is assumed to retard the seepage into L-31(N) (see comment 3). However, it was felt that this relatively impermeable layer was neither thick enough nor continuous enough to effectively reduce seepage around the 8½ square mile residential area. Therefore, only the transmissivity of the limestone was used to calculate seepage in this area. As a result, these seepage rates are considerably higher than those south of Tamiami Trail. During the FDM phase of the design, more aquifer testing will be done. The results of these tests will be incorporated into the models and analyses to provide the best representation of the aquifer that is possible.

9. The recommended plan in the GDM includes the structural features that would permit the greatest flexibility in the restoration of ENP. The operational criteria presented in the report are only a starting point. Operations will be evaluated and adjusted based on the performance of each plan. The basis of these adjustments would include restoration of the natural hydrology in ENP, flood control, water supply and water quality. However, the GDM recommends use of the MRD only if the parties involved (the Corps, the ENP, SFWMD, and others) cannot agree on an improved operating design.

from storage in Lake Okeechobee and would account for about a 12 percent increase in discharge from Lake Okeechobee to the South. It is stated in the GDM that if no other options are agreed upon by the agencies, that the MRD would become the official operating criteria by default.

The effect on the implementation of the MRD plan on South Dade Agriculture would be increased flooding potential by increased water levels in WCA 3A, NESRS, and by increased water levels in the L-31 N Canal caused by seepage. These increased water levels will in turn, cause the optimum or operational criteria at the structures to be exceeded more often than in the BRD Plan and thus the potential for releases through S-331 would increase. These releases, in turn, would impact flood protection in the L-31 N/ L-31 W/ C-111 basin just as it has in the past. The adoption of the BRD Plan over the MRD Plan would lessen the flood risk to South Dade agricultural and would allow this water to be used for other purposes.

Sincerely,

Bradley G. Waller
Principal Hydrologist
Miami, Florida
October 31, 1990

cm

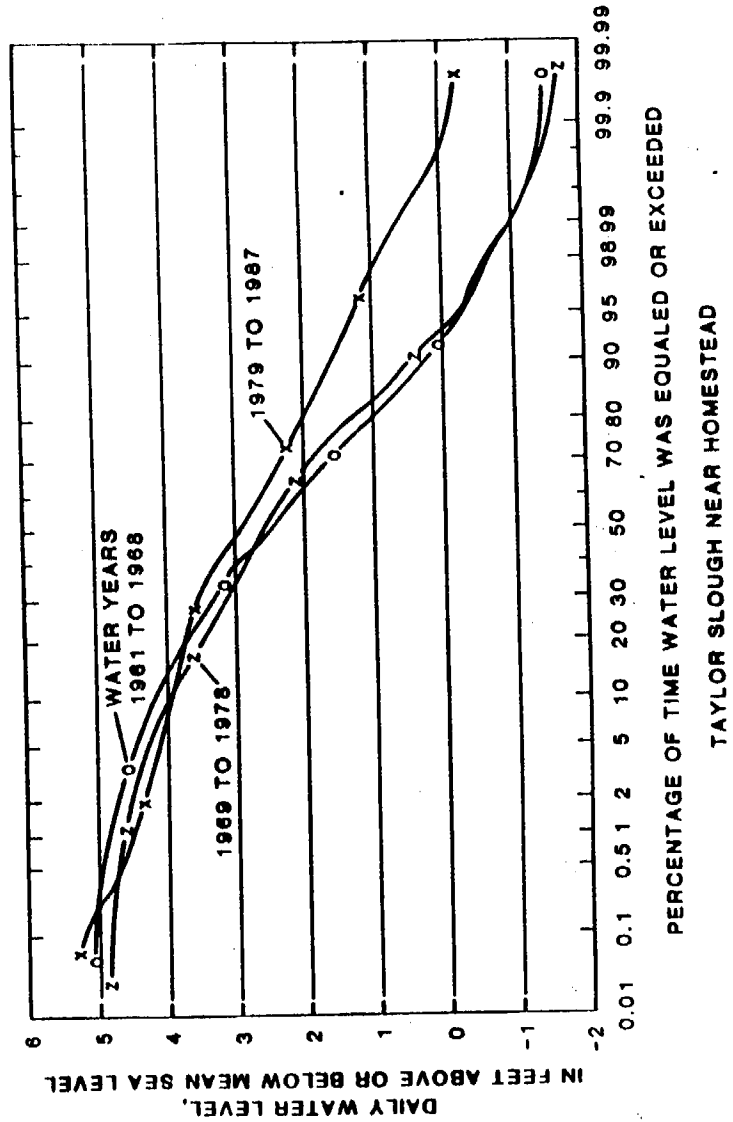

Table -- Mean monthly water levels at Taylor Slough at Royal Palm,
October 1968 through September 1980.
(Data from the records of the U.S. Geological Survey)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEP	WATER YR.AVE
1969	4.24	3.29	2.01	2.41	2.31	1.86	1.72	2.16	4.13	3.57	3.41	3.72	2.90
1970	3.84	3.70	2.73	2.58	2.58	2.15	1.28	0.38	2.89	3.32	2.21	2.46	2.51
1971	2.84	2.42	1.38	1.20	0.96	0.46	-0.43	-0.80	0.98	2.22	1.99	2.63	1.34
1972	2.50	2.28	1.89	1.72	1.81	1.30	1.84	2.27	3.63	3.60	2.97	3.45	2.43
1973	2.91	2.67	2.17	2.04	1.81	1.27	0.78	0.40	0.70	2.76	3.49	3.84	2.07
1974	3.33	2.20	1.91	1.88	1.08	0.59	0.02	-0.57	1.34	2.86	3.19	2.60	1.71
1975	2.65	1.83	2.07	1.31	0.66	0.20	-0.14	-0.38	1.87	3.35	2.94	2.86	1.56
1976	2.62	2.40	1.54	0.96	0.87	0.76	0.35	1.52	3.43	2.99	3.27	3.88	2.05
1977	3.01	2.46	1.86	1.81	1.78	1.35	0.39	2.10	3.60	2.51	2.86	3.96	2.31
1978	3.04	2.31	2.62	2.38	2.33	2.41	1.93	2.39	2.77	2.72	2.75	3.64	2.61
1979	3.46	2.72	2.21	2.09	1.69	0.97	0.64	1.52	2.93	2.90	2.75	3.16	2.41
1980	3.39	2.50	2.56	2.16	2.28	2.04	1.95	1.66	3.00	3.50	3.04	3.5[illegible]	2.64
12 YEAR AVERAGE	3.13	2.57	2.10	1.88	1.66	1.28	0.81	1.20	2.61	3.03	2.91	3.31	2.21*

*2.21 is the monthly average over the twelve year period of record.

Table -- Mean monthly water levels at Everglades station NP-206,
October 1974 through September 1980.
(Data from the records of the U.S. Geological Survey)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEP	WATER YR.AVE
*1975	11.73	10.21	11.22	9.52	8.26	7.01	5.52	7.75	10.93	11.33	11.32	11.49	9.7[illegible]
*1976	11.43	10.76	6.85	7.75	7.34	7.76	7.43	9.58	12.28	12.08	12.03	12.26	9.96
1977	5.91	5.65	4.66	3.65	3.35	2.67	1.33	4.57	5.67	4.92	5.43	6.12	4.45
1978	5.15	4.71	5.20	4.60	4.44	5.16	3.60	3.88	5.07	5.75	5.80	6.11	4.96
1979	6.00	5.71	4.86	4.28	3.44	2.44	2.21	5.92	5.62	5.83	5.55	5.84	4.8[illegible]
1980	6.10	5.85	5.61	5.13	5.07	5.41	5.38	5.13	5.77	5.85	5.90	6.01	5.62
1975-1980 MON. AVE.	7.73	7.15	6.77	5.82	5.32	5.03	4.25	6.14	7.56	7.63	[illegible]	[illegible]	6.55
1975-1976 MON. AVE.	11.58	10.49	10.04	8.64	7.80	[illegible]	6.46	8.87	11.61	11.71	11.78	11.88	9.86
1977-1980 MON.AVE.	5.80	5.48	5.13	4.42	4.08	3.92	3.13	4.88	5.53	5.59	5.67	6.02	4.97

*1975 AND 1976 WATER YEARS REPORTED AS AN ARBITRARY DATUM.
DATUM FOR 1977-1980 IS MEAN SEA LEVEL

SOUTH FLORIDA

EVERGLADES AND SOUTHEASTERN COASTAL AREA

02290800 TAYLOR SLOUGH NEAR HOMESTEAD, FL

GAGE HEIGHT (FEET ABOVE DATUM), WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.95	3.59	3.25	2.68	2.18	3.27	2.19	.78	1.47	1.43	2.71	4.56
2	3.93	3.57	3.22	2.65	2.17	3.14	2.14	.81	1.39	1.40	2.76	4.53
3	3.90	3.49	3.19	2.63	2.15	3.04	2.10	1.18	1.32	1.48	2.93	4.53
4	3.88	3.42	3.15	2.60	2.12	2.95	2.05	1.20	1.36	1.54	3.08	4.53
5	3.87	3.37	3.11	2.58	2.09	2.88	1.99	1.19	1.41	1.65	3.15	4.48
6	4.02	3.28	3.07	2.55	2.07	2.81	1.94	1.16	1.57	1.74	3.14	4.45
7	4.00	3.19	3.03	2.53	2.06	2.74	1.89	1.20	1.55	1.78	3.04	4.43
8	3.95	3.11	3.00	2.51	2.05	2.68	1.84	1.26	1.50	1.79	3.02	4.41
9	3.93	3.09	2.97	2.49	2.04	2.64	1.79	1.24	1.47	1.79	2.94	4.49
10	3.87	3.04	2.94	2.46	2.02	2.62	1.73	1.19	1.50	1.80	2.89	4.51
11	3.89	3.09	2.91	2.43	2.01	2.59	1.68	1.14	1.50	1.80	2.85	4.56
12	3.83	3.34	2.90	2.39	1.99	2.54	1.63	1.07	1.48	1.78	2.79	4.52
13	3.76	3.39	2.89	2.36	2.08	2.58	1.58	1.01	1.45	1.76	2.73	4.50
14	3.71	3.38	2.88	2.34	1.99	2.68	1.53	.94	1.42	1.72	2.78	4.52
15	3.64	3.63	2.87	2.32	1.98	2.74	1.48	.87	1.38	1.70	2.80	4.48
16	3.60	3.84	2.86	2.30	1.96	2.88	1.43	.81	1.32	1.73	2.99	4.44
17	3.54	3.88	2.85	2.28	1.94	2.82	1.34	.76	1.27	1.73	3.51	4.40
18	3.49	3.86	2.84	2.25	2.24	2.57	1.34	.66	1.21	1.93	4.84	4.38
19	3.43	3.74	2.83	2.22	3.61	2.51	1.30	.63	1.16	2.32	5.21	4.32
20	3.37	3.71	2.82	2.21	3.75	2.45	1.26	.58	1.13	2.25	5.33	4.28
21	3.31	3.63	2.80	2.19	3.81	2.39	1.21	.53	1.10	2.19	5.33	4.25
22	3.25	3.56	2.79	2.17	3.80	2.35	1.17	.47	1.10	2.18	5.28	4.23
23	3.18	3.50	2.78	2.15	3.76	2.56	1.12	.41	1.16	2.21	5.19	4.24
24	3.13	3.51	2.89	2.22	3.71	2.51	1.07	.36	1.22	2.26	5.08	4.22
25	3.13	3.46	2.88	2.26	3.70	2.15	1.02	.30	1.21	2.34	5.00	4.34
26	3.07	3.43	2.86	2.28	3.62	2.43	.96	.28	1.20	2.73	4.93	4.50
27	3.01	3.39	2.83	2.26	3.58	2.44	.93	.87	1.24	2.93	4.86	4.58
28	2.97	3.37	2.79	2.26	3.40	2.39	.89	1.49	1.31	2.88	4.77	4.61
29	2.92	3.34	2.77	2.24	---	2.33	.84	1.56	1.37	2.66	4.70	4.70
30	2.86	3.30	2.74	2.22	---	2.28	.81	1.58	1.41	2.85	4.65	4.71
31	2.97	---	2.71	2.20	---	2.23	---	1.53	---	2.78	4.60	---
MEAN	3.53	3.45	2.92	2.36	2.63	2.62	1.46	.94	1.34	2.04	3.87	4.45
MAX	4.02	3.88	3.25	2.68	3.81	3.27	2.19	1.58	1.57	2.93	5.33	4.71
MIN	2.88	3.04	2.71	2.15	1.94	2.23	.81	.28	1.10	1.43	2.70	4.22

CAL YR 1980 MEAN 3.04 MAX 4.38 MIN 1.33
WTR YR 1981 MEAN 2.64 MAX 5.33 MIN .28

Miccosukee Tribe of Indians of Florida

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October 29, 1990

Col. Bruce Malson
District Engineer
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: Draft General Design Memorandum (GDM) and Environmental Impact Statement (EIS) for Modified Water Deliveries to Everglades National Park, Florida.

Dear Colonel Malson:

Thank you for coming to our reservation to discuss the draft GDM. We understand the purpose of this plan is to restore historic water flows into the Everglades National Park (ENP). The Environmental Impact Statement (EIS) Abstract States:

> "Since ecological restoration is believed to be intricately linked with reestablishment of natural hydrological conditions, planning involved consideration of spatial, temporal and volumetric aspects of historical water movement."

While we appreciate the efforts to restore flows to ENP, we believe that to ignore water quality is a serious flaw. It is obvious to the Tribe that the timing, distribution, and volume of water has a direct impact on water quality. The South Florida Water Management District (SFWMD) is developing a Surface Water Improvement and Management (SWIM) Plan for the Everglades which addresses water quality concerns such as Phosphorous loading. This plan does not address other water quality concerns, e.g., heavy metal poisoning of the food chain.

As we stated in our letter to your permits branch, dated October 6, 1989, requesting a public hearing for permit Application # 89IPD-20307, we believe that the Corps has a trust responsibility to this Tribe. That responsibility includes assurances through the checks and balances of the Section 404 process that no adverse impacts will occur on the federal reservation.

RESPONSES TO

Miccosukee Tribe of Indians of Florida — Letter of October 29, 1990

1. The water quality issue in the Everglades is broad, with many diverse concerns and players. The Corps will work closely with the SFWMD and the Florida Department of Environmental Regulation (DER) to ensure that the proposed project would not further degrade water quality.

Col. Maison Letter
October 29, 1990
Page 2

(2) As concerns the draft GDM, the following change in Part I, supplement 54, chapter B, (Problem Identification) page 10, 4th paragraph should be made. This states the Seminole Indians inhabited the area. This needs to be corrected to read Seminole and Miccosukee Indians.

(3) The Tribe has also included a Position Paper for your information. This Paper concisely outlines the Tribe's rights in Conservation Area 3A as dictated by Federal and State law. Nowhere in the draft GDM are these rights mentioned, much less recognized. Therefore, we respectfully request the Corps of Engineers to include the Tribe's rights in the GDM. We also remind the Corps of Engineers that our rights need to be protected, regardless of the option chosen. The Corps of Engineers is acting as our trustee in this endeavor.

Thank you for allowing the Tribe to comment on the draft GDM and EIS.

ON BEHALF OF THE MICCOSUKEE
TRIBE OF INDIANS OF FLORIDA

Sincerely,

Jasper Nelson

Jasper Nelson
Assistant Chairman

Enclosure

CC: Billy Cypress, Tribal Chairman
Marie Osceola-Branch, Government Programs Manager
Steve Terry, Land Resources Manager
Eugene Duncan, Water Resources Manager
Bobo Dean, Tribal Attorney

2. The GDM has been revised to reflect the comment.

3. Appendix I of the GDM has been revised to include information presented in the referenced Position Paper. This Paper sets forth the Miccosukee Indian rights primarily in WCA 3A and identifies the rights expressly acknowledged by the Settlement Agreement of 1982 that exist in favor of the Miccosukees. This Paper also identifies and acknowledges the rights of the SFWMD and the Corps to modify the water levels in WCA 3A for project purposes (page 3). The only item raised in the Paper that is not clear under present knowledge and information is the question regarding the application of State Water law to water rights and the regulation of water resources as being dependent on the law existing prior to 1982. It is not clear why 1982 is significant under review and reading of the Settlement Agreement and the resulting Federal legislation.

Miccosukee Tribe of Indians of Florida

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LAWMAKER

Position Paper

TRIBAL RIGHTS IN CONSERVATION AREA 3A

This paper outlines the rights of the Miccosukee Tribe of Indians of Florida within the tract of Everglades land known as Conservation Area 3A. The rights considered here are those derived from the Florida Indian Land Claims Settlement Act of 1982, which resolved a law suit between the Tribe and the State of Florida. This paper does not address the possibility of continuing aboriginal title in these lands. The Settlement Act preserves whatever aboriginal rights which previously existed in the tracts noted below, but does not create any new aboriginal rights. See 25 U.S.C. SS 1744 (b) (1).

This paper discusses three separate areas: the "Leased Area", all of which lies within Conservation Area 3A, the Federal Indian Reservations, which overlap and adjoin Conservation Area 3A, and the Use Permit Area within the Everglades National Park which lies south of Conservation Area 3A.

LEASED AREA

The Leased Area is subject to a perpetual lease from the State of Florida to the Miccosukee Tribe. Most of the Tribe's rights under the lease are spelled out in section 3 of the lease, as follows:

(1) The members of the Miccosukee Tribe have the right to hunt and fish for subsistence purposes and to take frogs for subsistence and commercial purposes. These rights are without restriction as to season and are not subject to licensing by the State of Florida. However, under section 2 of the lease the State

Game and Fresh Water Fish Commission may restrict hunting, fishing and frogging in the Leased Area when necessary in order to properly manage fresh water aquatic life and wildlife (but such restriction may be no greater than that imposed in surrounding areas and must be preceded by consultation with the Tribe). Furthermore, any restriction of Indian subsistence hunting, fishing or frogging must be preceded by a total restriction on any non-subsistence taking of the particular species and there must be a continuing need for restriction to conserve the species. State law requires each Miccosukee Indian exercising these rights to have an identification card issued by the Miccosukee Tribe.

(2) The Tribe is entitled to compensation for public hunting and fishing in the Leased Area (the lease provides access to the Leased Area for hunting and fishing and other recreational purpose regulated by the State of Florida and not inconsistent with the rights of the lessee).

(3) The Tribe and its members are entitled to engage in traditional subsistence agricultural activities in the Leased Area. Revenue-producing agricultural activities are permitted only with the prior approval of the Water Management District.

(4) The Tribe, and members of the Tribe subject to tribal regulation, may reside in the leased Area and construct "traditional homes" therein, but under section 6 of the lease this right is subject to the rights of the Water Management District under the flowage easement granted by the State of Florida on August 8, 1950 to the Water Management District to manage water resources in the Leased Area, including the right to regulate water levels, and the rights and obligations of the District and the Corps of Engineers with respect to the management of water resources in Conservation Area 3A.

(5) The Tribe, and its members under tribal regulation, may use the Leased Area for religious purposes.

(6) The Tribe and its members may take native materials from the Leased Area for tribal and commercial purposes, subject to the stated purposes of the lease (which includes the preservation of the Leased Area in its natural state for the enjoyment of the Miccosukee Tribe and the public and the preservation of wildlife and wildlife habitat).

project, conveyances, easements, grants, rules, statutes, or any other present or future lawful authority to manage, regulate, raise or lower the water levels within the Leased Area or Water Conservation Area 3, including but not limited to the Dedication from the Board of Commissioners of State Institutions of the State of Florida dated August 8, 1950.

There is, in addition, a special provision governing access to the Leased Area. Paragraph 7 permits the Tribe to mark the boundaries of the Leased Area, the close certain portions of the Leased Area to public access for traditional dwelling, religious, or agricultural purposes (with the written approval of the Game Commission) and to exercise remedies authorized by law against trespassers. Any individual entering the Leased Area for purposes not authorized by the lease is a trespasser. Limitations on access do not apply to employees or agencies of the Board (i.e., the State), the Water District, the Corps of Engineers or the Game Commission who enter the Leased Area "in the performance of their official duties."

While the rights of the Tribe are those of a lessee, and the State continues to own the Leased Area, the Tribe's rights as lessee are permanent and may only be terminated with the consent of the Tribe or (with respect to any portion of the Leased Area taken for a public purpose) upon payment of just compensation.

As a condition of the settlement the State of Florida enacted legislation which:

(a) provides that the Miccosukee Tribe exercises governmental jurisdiction within the Leased Area under State law as the governing body of a special improvement district, Fla. Stat. SS 285.18.

(b) confirming the Miccosukee Tribe's hunting, fishing and frogging rights in the Leased Area. Fla. Stat. SS 285.09 - 285.10.

The federal settlement legislation provided that the Tribe's interest in the Leased Area will be exempt from all state or local taxation and that the Leased Area will be treated as a federal Indian reservation for the purposes of determining the eligibility of the Tribe and its members for various federal programs assisting Indians. Under the federal legislation the State has the right to

(7) The Tribe has the right to fifty percent of any revenue derived by the state of Florida from the mineral interest in the Leased Area and the Tribe may prevent any subsurface exploitation which interferes with tribal uses or which does not best protect the natural state and beauty of the Leased Area.

In addition, the lease assures that the State agencies will not permit any revenue-producing facilities within one-half mile of the Leased Area (or the federal reservation) on state-owned land without tribal consent, and the Tribe and its members have the exclusive right to offer tourist services (airboat rides, guide services, etc.) within the Leased Area.

Two provisions of the lease which limit tribal rights should be set out in full. Paragraph 5 provides as follows:

5. Limitations on Tribal Use. Subject to the provisions of paragraph 6, use of the Leased Area by the Miccosukee Tribe shall comply with all applicable laws and regulations in effect on the effective date of this Lease Agreement (including but not limited to Chapter 373, Florida Statutes), with the lawfully enacted ruled and regulations of the SFWMD, both presently existing and those which may be promulgated in the future, and with all future laws and regulations not inconsistent with rights granted the Miccosukee Tribe under this Lease Agreement. The Miccosukee Tribe shall possess no exclusive or private rights of access to and from Alligator Alley in the Leased Area, and highway access by the Tribe shall be subject to regulation by the State of Florida and the United States.

Paragraph 6, which is discussed above, provides:

6. Rights of South Florida Water Management District. The Leased Area has for many years comprised a portion of a large reservoir utilized for the flowage and storage of water servicing the area of Broward, Dade, Monroe and Collier Counties and designated as Water Conservation Area 3 as part of the federally authorized project of flood control and water management for central and southern Florida. The Commission and the Miccosukee Tribe agree that all of the rights set forth in paragraphs 1 through 5 and 7 are subject to and shall not interfere with the rights, duties and obligations of the SFWMD or the United States Army Corps of Engineers, pursuant to the requirements of the aforesaid federally authorized

exercise the power of eminent domain in the Leased Area without federal consent but must pay just compensation. 25 U.S.C. SS 1745.

Background

The lands included within the Leased Area have been occupied and used by the Miccosukee Indians for many years. Prior to April 5, 1960, the State of Florida did not recognize that the Indians had any right to reside in the Leased Area, although state legislation accorded the Indians certain hunting and fishing rights on State-owned lands. Following extensive negotiations between the Governor and other state representatives and the Tribe, the Governor and Cabinet approved a license on April 5, 1960 covering a portion, but not all, of the present Leased Area. The license was revocable by the state upon a finding that revocation was in the interest of the state, but did assure that the Indians could not be considered trespassers on State land in the licensed area. The Indians did not, at the time the license was negotiated, understand that the license provided no guarantee against revocation, and soon after its issuance began new negotiations for a more permanent arrangement.

Lengthy negotiations with the State, including a public hearing and the filing of a tribal law suit against the State identifying significant legal claims of the Tribe against the State (a claim based on the flowage easement granted by the state to the Water District over reservation land, a claim based on the Alligator Alley right-of-way over reservation land, and a claim based on the executive order reservation of 1839-1842 which set aside 5,000,000 acres for Indian use) ended in a settlement agreement which was confirmed by Congress in the Florida Indian Land Claims Settlement Act of 1982 in which the Tribe waived all these claims and, as well, its claim of aboriginal title to substantially the whole State of Florida. In exchange for relinquishing these claims, the Tribe received the rights in the Leased Area enumerated above, the transfer of the Broward County reservation and three parcels previously deeded to the Tribe by the State along the Tamiami Trail to the United States in trust for the Tribe, and modest monetary payment ($975,000).

FEDERAL MICCOSUKEE RESERVATION

The United States holds title in trust for the Miccosukee Tribe to five tracts of land. The former State Indian Reservation

in Broward County was transferred to the federal government pursuant to the Florida Indian Land Claims Settlement Act of 1982. 25 U.S.C. SS 1747. This Act also provided for the transfer to the United States in trust for the Tribe of three parcels located on U.S. Highway 41 in Dade County which had been previously deeded to the Miccosukee Indians by the State. These four parcels were conveyed to the United States by the State of Florida by a trustees' deed, dated March 3, 1983 and were accepted on behalf of the Secretary of the Interior on June 11, 1984. In addition, a fifth tract located at U.S. Highway 41 and Krome Avenue in Dade County has been conveyed to the United States in trust for the Miccosukee Tribe and was proclaimed by the Secretary of the Interior as an Indian reservation for the exclusive use and benefit of the Miccosukee Tribe on July 31, 1990 pursuant to 25 U.S.C. SS 467. Except for the Broward County reservation, these lands are outside Conservation Area 3A. However, approximately the eastern half of the Broward county reservation (the lands subject to the Water District's flowage easement) are included in the conservation area, and the other tracts are all located near Conservation Area 3A.

In its reservation land, the Miccosukee Tribe holds full beneficial title and is entitled to the complete enjoyment of such lands, subject to the federal laws applicable to Indian trust lands (which regulate the conveyance and leasing of such lands and similar matters) and other laws of general application which apply to Indian tribes (such as federal environmental laws) and, except for the fifth tract, to specific state regulatory statutes relating to alcoholic beverages, gambling and the sale of cigarettes. 25 U.S.C. SS 1747 (b) (2). With respect to the Broward County reservation, the conveyance to the United States is subject to the rights of the Water Management District under its flowage easement. In accordance with the settlement agreement and the federal settlement legislation the deed provides that the conveyance does not increase, diminish, modify or otherwise affect the extent to which the Florida statutes regulating water rights and resources (Florida Statutes, Chapter 373) applies to the reservation. The extent to which State law relating to water rights and the regulation of water resources applies to the reservation is thus dependent of what the law was prior to 1982. The Tribe and the Water District are currently engaged in negotiations to define tribal water rights and to provide for the regulation of water resources appurtenant to the federal reservation in a water compact.

Background

The State of Florida established a reservation for the Miccosukee Indians in Monroe County in 1917. Fla. Stat. SS 285.01. In 1935 that reservation was abolished and another reservation was authorized to be established in Broward County. Fla. Stat. SS 285.06. The present Broward County Miccosukee reservation consists of the southern portion of the State Indian reservation authorized in 1935. The Broward County reservation was provided to the Tribe in an attempt to rectify the injustice involved in the abolition of the Monroe county reservation. The Broward county reservation was subsequently partitioned between the Seminole Tribe and the Miccosukee Tribe. Fla. Stat. SS 285.061. The Miccosukee portion of the State reservation was conveyed to the United States in trust for the Miccosukee Tribe as discussed above.

USE PERMIT AREA
(EVERGLADES NATIONAL PARK)

The Miccosukee Tribe occupies an area approximately five miles long by 500 feet wide just south of the northern boundary of the Everglades National Park. The Tribe's rights in this tract derive from a Special Use Permit issued by the Secretary of the Interior on February 1, 1973. Under the terms of the permit the Tribe and its members are entitled to live, make and sell handicrafts within the permit area and to construct administrative, operational, educational, medical and community facilities. Although its rights under the permit are not permanent, the Tribe's principal community and headquarters are located within the permit area. Within this area the Tribe has the right to provide for both community and individual facilities and to engage in governmental and commercial activities. Construction, dredging and filling within the area is subject to the approval of plans by the National Park Service. The Tribe is not subject to the jurisdiction of the State of Florida within the permit area. However, its activities are subject to various federal laws and regulations, including those applicable to the national parks and federal environmental laws. The permit provides that water rights will be perfected in the name of the United States for water developed or used in connection with the permit.

Background

Following the abolition of the Monroe County reservation, the National Park Service attempted to remove the Miccosukee Indians from the Everglades National Park. In 1964 the Secretary of the Interior intervened and on January 24, 1964 issued a permit to the Bureau of Indian Affairs which allowed the Miccosukees to remain within the present permit area. The Secretary replaced the 1964 permit with the permit issued to the Tribe in 1973, a step in keeping with the federal Indian self-determination policy which resulted from the President's 1970 Message to the Congress on Indian Affairs. Since 1973 the Tribe has been responsible for managing the use of the permit area, subject to approval of certain actions by the National Park Service. It has established a law enforcement program under tribal authority funded by the Bureau of Indian Affairs, and has developed facilities within the area for health, education, tribal government, recreation and residential use by Miccosukee Indians.

Consulting Engineer Landscape Archit

PO Box 43-1202
South Miami, FL 33143
(305) 271-0288

October 30, 1990

Mr. Louis Hornung
Modified Water Deliveries to
Everglades National Park, Florida
Plan
Corp of Engineers
P.O. Box 2970
Jacksonville, FL 32232-0019

Dear Mr. Hornung:

RE: **COMMENTS** On
"Modified Water Deliveries
to Everglades National Park, Florida,
General Design Memorandum, Environmental
Impact Statement and Appendices"

Dear Mr. Hornung:

The two volume "General Design Memorandum" for the above project was just received. It is very difficult to review the approximate 1000 pages in a short time.

In the past I have represented the agricultural interests of Senior Corp and currently repesent the persons who purchased Senior Corp's land and permits in the East Everglades. These properties are located in Section 6 and 7, Township 57 South, Range 38 East, and Sections 19 and 30, Township 56 South, Range 38 East. I also represented the agricultural interests of "Doctor's Ranches" in Section 3, Township 55 South, Range 38 East.

The concerns of my past and present clients are that the project will increase water levels over their previous levels and increase the area subject to "wet land" permits. Hitting the moving target of "wet land" definition and environmental constraints is difficult enough without having to contend with artificially re-introduced higher ground and surface water levels.

(1) If you study the physiographic provinces, there is one feature that appears to have been overlooked, (See "Trees of South Florida", Page 58, by Frank C. Craighead, Sr.). That is the Grossman Hammock Rock Reef and its continuation on the west side of North East Shark River Slough. This is a long narrow rock ridge. This phenomena raises abruptly 2 to 4 feet above the surrounding marl floor. These appear as a

RESPONSES TO

Mr. Harold R. Cobb — Letter of October 30, 1990

1. Since calibration of gages in Shark River Slough and Chekika Park were good, the effect of the Grossman Hammock Rock Reef was not considered. Additionally, stage data collected at gages upstream and downstream of Grossman Ridge indicated the ridge did not have a significant impact.

series of tree islands across the Shark River Slough. The effect is of a weir. Upstream the water surface is higher and downstream lower. The rock ridge acts to retard the flow of water. The eastern end is about 10 miles south of Tamiami Trail (This is now called Chekika Hammock by the Florida Department of Parks) and extends generally north westerly for 7 miles where it is eroded (this is about he southern end of Levee 67 extension). The rock reef is difficult to follow in this area. The rock reef then continues north west until it disappears into the Cypress Ridge about 10 miles farther west. There are several smaller remnant reefs south of Grossman Hammock Rock Reef that also affect the flow of ground and surface water. Context Road west of Homestead General Aviation Airport has the same effect on Taylor Slough. The flow in Taylor Slough starts when the ground water elevations south of Chekika Hammock State Park exceeds the ground elevation.

(2) The average ground elevations shown on Figure D-9 do not correlate with known ground elevations on Senior Corps property or with contour maps used in the "East Everglades Planning Study". They appear to be lower.

The canal for L-31-N acts to draw down the ground water for 1 to 2 miles west. In engineering terms, the canal acts as a "line sink". The adjacent land is in effect over drained by the canal. You can expect to have the same effect following the canals rimming the residential area.

(3) The North East Shark River Slough flows south west. The effect of your plan is discharge water farther east along the Tamiami Trail so it can then follow the North East Shark River Slough to the south west. This requires flood protection for the residential area, which would not be required if you did not move more water to the east. It does not make any sense.

More important, the base line computations support the claims of Senior Corp and the present property owners that their property is not "wet land" by the current definition. The denial of "dredge and fill" permits on these properties was in error. Senior Corp and the current property owners are now in position to ask not only for re-consideration but to ask for waiver of jurisdiction on these properties that permits were wrongfully withheld.

Yours truly

Harold Cobb
Consulting Engineer

2. The model will be updated as new topographic data becomes available.

3. Concur that flood mitigation (protection) would not be necessary if water deliveries to NESRS were not spread to the east. However, the goal of this project, in consonance with the expansion of ENP, is to reestablish natural hydrologic conditions. This goal requires that water be spread across the historic flow-way, includes NESRS. The provision of flood mitigation to the residential area is a cost of the hydrologic restoration of NESRS.

MEMORANDUM

October 30, 1990

C. Leroy Irwin, Administrator, Technical Policy & Analysis

Joe Gomez, District Six PD&E Engineer

Barbara Bernier, Christie Pritchard, Mike Chacar

General Design Memorandum, U.S. Army Corps of Engineers
Modified Water Deliveries to Everglades National Park, Florida
Central and South Florida Project for Flood Control

As requested by the U.S. Army Corps of Engineers, we have reviewed the subject GDM/EIS and are pleased to offer the following comments:

1.) The GDM offers significant details in managing Conservation Area's 3A and 3B. While the Department's jurisdiction lies outside this general area, we are pleased to see this type of planning from the ACOE and believe it will be extremely beneficial to the Everglades National Park and adjacent areas.

2.) The ACOE is proposing to raise SR 90/US 41/Tamiami Trail approximately 7.1 feet in the area adjacent to Structure S-334 for a distance of approximately 150 feet. Since Tamiami Trail is a two-laned undivided rural arterial, the proposed profile must be design in conformance to AASHTO requirements for passing sight distance. Additionally, it will be necessary to construct a temporary two-laned road which meets minimum standards for safety and speed as required by AASHTO. The ACOE will need to transmit plans to the Department in order to secure the necessary roadway alteration permits prior to construction.

Thank you for the opportunity to comment on this document.

RESPONSES TO

Florida DOT

Memorandum of October 30, 1990

1. Proposed works in the Tamiami Trail will conform with AASHTO standard and would be coordinated with your organization.

METROPOLITAN DADE COUNTY, FLORIDA

METRO-DADE CENTER

ENVIRONMENTAL RESOURCES MANAGEMENT
SUITE 1310
111 N.W. 1st STREET
MIAMI, FLORIDA 33128-1971
(305) 375-3576

October 30, 1990

Colonel Bruce Malson, District Engineer
US Army Corps of Engineers
P.O. Box 4970
Jacksonville FL 32232-0019

Dear Colonel Malson:

Dade County appreciates the opportunity for reviewing and commenting on the General Design Memorandum (GDM) for Modified Water Deliveries to Everglades National Park and the Draft EIS for that GDM. The County is on record as strongly supporting the restoration of Everglades National Park and the Park expansion into the NE Shark River Slough. The County supports the concept of a raindriven water delivery formula as described in the GDM and the construction of the S-349, S-346, and S-356 structures and the removal of the L-67 extension Levee and canal.

We welcome the work that has been done to date and realize that it is important to move ahead as quickly as possible. However, we do have some concerns about the GDM and its potential impacts on the regional water supply system. The GDM will cause a decrease in water that is available within the system. The water supply issue may be further exacerbated by the reduced water flows that are contemplated in the SFWMD Everglades SWIM Plan. This is of major importance to Dade County because we are dependent upon the system for replenishment of regional wellfields and for maintenance of salt water barriers. (1)

We are also concerned about the degree of uncertainty that exists about the operational criteria for the structures and pumps. Depending upon the criteria used, there could be further reduction in water supplies to the lower east coast. It is important that the GDM include a program for monitoring and evaluating hydrological, water quality and biological data for the entire project area. The operational impacts must be carefully monitored in the initial phases of plan implementation and those data must be evaluated to refine the operational criteria. Dade County requests that it be included in the development of the operational and management criteria for the GDM structures and pumps. (2) (3)

Several of the County's concerns are related to the East Everglades Residential Area. We understand that a decision was made approximately two years ago to provide flood mitigation for

RESPONSES TO

Metropolitan Dade County — Letter of October 30, 1990

1. Impact of the project on the regional water supply system would not be significant on a long-term basis. This can be seen on Figures E-89 through E-163. Figure E-109 compares Lake Okeechobee storage for the base condition and modified rain-driven plan for the 14-year period simulation. No significant changes in storage can be observed with the project. The final GDM addresses the water supply issue in more detail. For example, several tables showing a comparison of changes in storage in the WCA's, Lake Okeechobee, and total system for several wet and dry years would be made. These tables show no significant impact to the water supply in the region. These results would improve with the development of a better operating criteria in the future, specially with a better simulation of the Modified Rain-Driven alternative. Results of modelling of this alternative do not include the impact of the S-349 structures. With these structures water deliveries to WCA No. 3A would be reduced significantly.

2. The recommended plan in the GDM includes the structural features that would permit the greatest flexibility in the restoration of the Everglades National Park. The operational criteria presented are only a starting point. Operations will be evaluated and adjusted based on the performance of the plan. The basis of these adjustments will include restoration of the natural hydrology in ENP, flood control, water supply and water quality.

3. For biological monitoring, see response to comment #4 in Dr. Frederick's letter (page F-8). For water quality monitoring, see response to comment #2 in F.A.D.E. letter (page F-4).

that area rather than to buy the owners' property. However, we continue to be concerned about the long term implications of that decision.

(4) While the Park Expansion Bill eliminated the need for a formal cost/benefit analysis, it may not be cost efficient to provide flood mitigation through structures and pumps when long term maintenance and operational costs are considered. The need to reduce fossil fuel consumption may make a long term, energy intensive solution economically and environmentally undesirable.

(5) The incidental flood protection for the East Everglades Residential Area that is referred to in the Draft EIS implies that there may be impacts to the NE Shark River Slough. Therefore, it is imperative that a network of groundwater monitoring stations be established throughout the NE Shark River Slough with good coverage adjacent to the residential levee system and L-31N. The operation of the flood mitigation system must be tied to the monitoring network observations; if impacts are observed west of the residential levee, then corrective measures must be taken to reduce impacts within the Slough.

As you are aware, the issue of incidental flood protection is particularly sensitive for Dade County, because the County Code authorizes an increase in residential density in the East Everglades Residential Area if one in ten year flood protection is provided. For that reason, the project wide monitoring program should provide the hydrological and operational data that the county will need to evaluate and field verify the degree of flood protection that is provided once the system is fully operational.

(6) There is also a potential for water quality degradation in L-31N as a result of direct surface water discharges into the residential canal system. Contaminants in the stormwater runoff from this rural residential/agricultural area could degrade the quality of the water that will be delivered directly into the NESRS portion of Everglades National Park and used to supply public and private potable water wells in Dade County.

(7) If it is determined that the degree of incidental flood protection will permit increased development in this area, the potential for water quality degradation may also be increased. This is significant because this project must meet the sole source aquifer requirements that are applicable to all federal projects.

(8) This potential problem may be alleviated, in part, by constructing a low berm on the east side of the residential canal system to intercept the first few inches of direct runoff. It will also be essential to closely monitor water quality in L-31N and L-29. The costs for water quality monitoring and potential remedial actions should be included in the estimated costs for flood mitigation for the East Everglades Residential Area.

4. Non-structural alternatives were not cost effective for mitigating project impacts in the residential area.

5. As part of the testing procedure, monitoring of the groundwater and surface water will provide hydrological and operational data for evaluation of the effects outside the residential levee. A network of monitoring stations will be established during the later stages of construction.

6. During detailed engineering design of the flood mitigation system, the addition of the buffer strip requested by the Park inside the levees and canal will be addressed. Such a buffer strip might reduce or eliminate potential water quality problems resulting from overland flow across developed areas into the seepage collection canal. Also during these studies, the addition of a small berm to block overland flow would be considered. Incidental diminution of flood risk is an unavoidable consequence of a project designed to mitigate adverse impacts.

7. Future development is dependent upon Dade County's zoning. Without changes in zoning, no significant change in development density will occur. Changes in Dade County zoning regulation may result in a need for the County to provide additional water quality monitoring.

8. The feasibility of using a low berm in conjunction with a buffer zone will be evaluated (See response 6). Control of water quality is a local responsibility, and any costs would be borne locally. The details of monitoring will be considered during the post-GDM design period.

Our final area of concern is related to the proposed West Wellfield. As mandated by the Park Expansion bill, the West Wellfield must not cause any significant adverse impact to the NE Shark River Slough. Therefore, we are preparing a Wellfield plan that will include several new structures and canals to avoid adverse impacts to the Slough.

One important component in the West Wellfield Plan is the operation of G-211 to intercept water that will leak from the NESRS into L-31N. That structure can make water available for re-introduction into the Park expansion area rather than discharging water south where it would become a major problem for the C-111 GDM. Dade County strongly recommends that the G-211 structure remain in operation as a part of this GDM. (9)

The Corps of Engineers is to be commended for the quality of the GDM and Draft EIS documents. They provide an excellent beginning for the essential task of Everglades restoration, which must be a flexible, iterative process, due to its complexity and magnitude. As a major user and component of the lower east coast water management system, Dade County will continue to support and actively participate in the development and refinement of the operational and monitoring elements of this plan. If you would like to discuss any of these comments in greater detail, please contact Pedro F. Hernandez of DERM at 305-375-3376.

Sincerely,

John W. Renfrow, P.E.
Director

9. G-211 was built on a temporary basis to raise canal levels north of the structure. Future modelling with and without the structure would be conducted to assess its impact. Results of the modeling would determine the potential benefits of the retention and use of this structure for operation of the project.

Mr. A. J. Salem
Chief , Planning Division
Environmental Resources Branch
Department of the Army
Corps of Engineers
P.O. Box 4970
Jacksonville, Fla. 32232-0019

October 30, 1990

Dear Mr. Salem:

I believe the proposed pump station S-357 is essential to diverting seepage out of our residential area. Although pumping into L-31N an over taxed staging area for floodwaters flowing from all property west of the ridge line running under US 1. Would not seem to give our community any relief ether during or after any type of major storm, tropical or local. This S.F.W.M. practice is as such that the adequate pumping ability of S-356 to handle C-31N water is very important . Pumping westward on C-4 preferred rather than the S.F.W.M.'s present practice which is my other concern.

At times over abundant rainfall water needed in Taylor slough and N.E.S.R.S. is diverted into Barnes Sound , Manatee Bay and Biscayne Bay. Wasting needed resources and causing sudden salinity changes, causing Barnes Sound to become varietally barren of life for long periods afterwards at this writing the fish population is still very sparse compared to populations before last years opening of the earthen spillway on C-111.

The "Modified Rain Driven Plan " appears to the most sensible for all concerned but water modifications properly made well in advance of sever storms are always our concern. The complete removal of L-67 ext.. levee will relieve the bottleneck at the south end of N.E.S.R.S. caused by L-67 ext.. running north & south and the Chekika hammock ridge running east & west to within a 1/2 mile of each other . This narrow area of has adverse effect the residentual area during sudden rains in combonation with water releases through the weirs on the north end of N.E.S.R.S.

Our concern for our safety and cotenued use of our homes and lands in the community are on all of our minds. The elivation of the propertys here are only 6" to 12" different than that of the Kendall area at 8 to 8.5 above sea level. My property was at a 7.5 to 8.1 level overall prior to construction or soil enhancement 14 years ago. Odveusely there is little margen for erorr when it comes to flood controls . The ability to move groundwater more efficently westward prior to and after major weather fronts and storms, is preferable to open dumping into the bays

Avoding a saturation point of groundwater in our community and keeping groundwater levels in the residentual area at a 5 to 5.5 as much as possible, would be much prefered. Rather than the wild fluctuations of water levels in the years prior to '81 Tropical Storm Dennis. The watertable rose to a level 4" above the groundlevel over the majority of the property. The water shed off of and through the property for 3 days coming from the southwest moving northwest toward N.E.S.R.S..

(1)

Seepage from L-31N was my biggest problem and my biggest concern in future storms. Being my property is only 600' L-31N, I walk the levee most afternoons down to the S-331 pumping station. On many occations I have checked the water level markers at that location on C-31N over the last 14 years. These observations along with flying over the N.E.S.R.S and Chekeka Hammock for 5 years also visiting the hammock and slough since 1965. These and being a Dade resident since 1954 are base of my personal experiance in this Area.

Sincerely,

Landon E. Thomas
Resident of E. Everglades
18990 SW 152 St.
Miami, Fla. 33187

RESPONSES TO

Mr. Landon F. Thomas — Letter of October 30, 1990

1. The residential area flood mitigation system is not designed to prevent natural damages that may occur without the project. The purpose of the system is to mitigate for additional impact the project would cause. However, your seepage problem could have some relief with the addition of the G-211 culvert structure, located below C-1.

The Everglades Coalition
900 Seventeenth Street, N.W.
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Washington, D.C. 20006-2596
Tel: 202-429-2681, Fax: 202-429-3958

October 31, 1990

Dr. Jonathan D. Moulding
US Army Corps of Engineers
PO Box 4970
Jacksonville, FL 32232

RE: Modified Water Deliveries to Everglades National Park

Dear Dr. Moulding:

The undersigned organizations, members of the Everglades Coalition, submit the following as comment on the US Army Corps of Engineers Draft General Design Memorandum and Environmental Impact Statement on Modified Water Deliveries to Everglades National Park, Florida. Please note that among our member organizations, the Florida Wildlife Federation and Sierra Club have differing views on aspects of the DGDM/DEIS, and will submit separate comment.

General

A central view of the Everglades Coalition and its constituent organizations is that establishment of more natural water regimes is essential to restoration of natural values in Everglades National Park.

The degradation of the Park and other public conservation areas is the consequence of systematic alterations; their restoration must be addressed, and modifications made, systematically.

The Coalition lent its firm support to the Everglades National Park Protection and Expansion Act of 1989, because it offered the opportunity to effect changes in the management of water flows that would benefit the Park and would characterize changes needed to restore and preserve the balanced natural evolution of the Everglades' native flora and fauna.

In the Everglades historic condition, the slow-flowing marshes attenuated the rise and fall of surface waters. As a result, wetlands up-gradient supplied the Shark River Slough into the dry season, and supplied refugia in drought. The system's plants and wildlife are unadapted to the discharge spikes, rapid recessions, artificial ponding, swings in estuarine salinity, and degraded water quality, that present management conditions induce. As a result, operation of the Central and Southern

Florida Project saps the native vitality of the system. It results in loss of population and diversity from periphyton communities to large predators. Remnant populations, including some of species now endangered, have been forced to rely on special, artificial, and, therefore, inherently unstable conditions in the system

We support restoration plans that move toward replication of natural events and processes in the most complete possible fashion. We support restoration plans for limited areas that can be most effectively integrated with such plans in the system generally. As the present regime has resulted in spatial, temporal and volumetric distortions in the system's hydrology, each restoration component -- indeed each present action in the hydrologic system -- should offer the greatest possible opportunity to reduce those distortions in each of their dimensions.

Structural Plan

The Everglades Coalition supports the full range of structures proposed in the draft GDM. They are required to fulfill the objectives of the rainfall-driven alternatives, which we believe to be the only alternatives responsive to the 1989 Act and other provisions of law and sound policy. We suggest consideration of broader spacing in the S-345 and S-355 structures, to more closely emulate natural conditions of sheet flow. We suggest consideration of passive structures, like earthen plugs, as a substitute for the S-349 structures, to more economically meet necessary conditions of L-67 operations. If it can be accomplished without diminution of the project's effect in restoring more natural water flows to the system, we suggest that structures placed in L-67 be designed -- and signed -- to permit safe passage of fishing boats. (1)

Operational Objectives and Alternatives

We concur in the observation of the DEIS (Section 4.57), that Shark River Slough restoration requires restoration of more natural hydrologic conditions in WCA 3B, and would extend the observation to include WCA 3A and the entire front of the Slough. Reducing southward flows in L-67, restoring surface water flows to WCA 3B, and from WCA 3B to the Slough, are all necessary to the restoration objectives, and to increased vitality of the southern Everglades.

Eliminating or reducing any aspects of the plan from those proposed in the Basic Rain-Driven alternative loses benefits to be derived from increasing marsh residence times in the WCA's, from reducing impacts of heavy regulatory releases, and from restoration of hydroperiods in the WCA's and the park.

Loss of flows to the sloughs and mangrove swamps of the park are a primary cause of the diminished diversity and productivity of its natural life. Much of that loss is induced far upstream, and similarly affects the Water Conservation Areas. Making the best use of presently available water resources is a vital predicate to any realistic hope of general improvement.

RESPONSES TO

The Everglades Coalition — Letter of October 31, 1990

1. Since coordination of the draft GDM, the S-345's and S-349's were relocated and spread farther apart. This change is reflected in the revised GDM.

We note that both rainfall-driven alternatives produce more frequent drydowns and a lower volume of lagging flows in the Slough than simulations of natural conditions demonstrate. That, to us, indicates that greater quantities of water will be required for successful restoration of affected ecosystems, and that reformed management of system supplies, generally, is needed. We note that the Base and Modified Base alternatives do not provide natural timing or distribution of flows, and result in more destructive releases and more frequent, untimely drydowns. That, to us, indicates that they would produce a poor use of available supplies, that they would not produce responses commensurate with improved supplies, and that they would increase the harm resulting from further restrictions in the general supply.

(2) We suggest that present criteria will result in too infrequent releases from WCA 3A to WCA 3B. Restoration of more natural flows in WCA 3B requires response both to rainfall- driven and regulatory criteria. Restoration of hydroperiods in WCA 3B and the park would appear to require inflows at the S-345's balanced with outflows at the S-355's. We ask that the feasibility of so modifying the operational criteria be considered.

(3) Benefits to be derived from delivering water to the Slough through WCA 3B may be increased by increasing the proportion of such deliveries. We suggest consideration of increasing the presently proposed 51% of deliveries via the S-355's to 70-75%.

Further Development and Monitoring

The summary describes ecological restoration of the park through "...an evolutionary and dynamic process requiring many years of iterative field testing of water delivery strategies in conjunction with an environmental monitoring program."

(4) As the criteria and appropriate techniques for management of the project will be determined in that extended process, it is vital to provide, as an enforceable condition of project operation, for required monitoring, testing and evaluation. A process by which impacts of new water management strategies will be effectively monitored, evaluated, and adapted, should be detailed in the GDM, and responsibilities for funding and program implementation clearly stated.

(5) Because of the volume and variety of human influences on Everglades ecology, monitoring and evaluation of water management strategies must extend to the maximum practical range. Water delivery strategies at the S-12's and S-355's are subject to those engaged for the C&SF project, generally, and associated with choices made beyond or beside federal jurisdiction. The critical role of the South Florida Water Management District in its present development of water quality and supply plans is an obvious example. We suggest that the GDM and FEIS affirm water allocations and requirements in the park, Loxahatchee NWR and the other WCA's, and Big Cypress National Preserve as it may be affected by operation of the S-343's and S-344, together with intergovernmental processes by which the restoration of park flows and protection of the Everglades system can be effectively and jointly advanced.

2. Operations of the structures will be developed through an iterative testing process to maximize project benefits.

3. The current goal is to deliver 55 percent through the S-355's and 45 percent through the S-12's. This ratio may be revised if necessary when more data become available.

4. See response to comment #4 in Dr. Frederick's letter (page F-8).

5. See response to comment #2 in National Audubon Society's letter (page F-18).

Eminent in such assessment should be the question of coordinating and evaluating monitoring programs from various agencies, and the ecological impacts they see derived from the resultant data. We are particularly concerned by the present conflict, as expressed by the US Fish and Wildlife Service, between the objective of restoring the park's water flows and health of the Snail Kite.

In the Draft GDM, it appears that the Basic Rain-Driven alternative goes furthest toward providing more natural timing, distribution and seasonal precession of water flows in the park and the associated WCA's. We believe it is probably erroneous to conclude that the alternative will result in jeopardy to the Snail Kite, or that modifications made for the Kite's supposed benefit will not harm other endangered and threatened species. The Everglades' increasingly adverse general condition has generated a long, sad list of such species. Water management choices made in the Everglades over the last fifty years, and the resulting hydrological insult to the natural system, has put many of them on that list. We believe that the proper course in this matter is to initiate a comprehensive, integrated consultation or conference, as appropriate under the Endangered Species Act for all listed, proposed or candidate species in the C&SF project area, in relation to the instant GDM, the C-111 GDM, other planned project modifications, and the project's continuing operations.

(6)

Such a course may seem formidable, but it is not more formidable than the problem of endangered species in the Everglades, and it offers the prospect, at last, of dealing with those species as inhabitants of an ecosystem and not, like zoo animals, as a set of feeding, breeding and veterinary requirements. It offers the prospect, too, of a continuing, effective instrument in evaluating the many other federal actions subject of Section 7 of the Act, and for considering the true and neglected requirements of its Section 9 "taking" prohibitions.

We may here have chosen the most difficult example, and prescribed the most difficult approach, but we conclude that it properly illustrates the need for extensive, coordinated action in monitoring and evaluation of project effects, and the need for application of knowledge from a wide array of sources.

The Nation has set a goal of comprehensive human management of the system, and, simultaneously, determined to hold portions of it to the highest, most durable standards of natural protection that our society affords. As a consequence, we are forced not only to restore but to replicate natural processes of tremendous complexity; a job sure to tax the best abilities of every individual and institution involved.

The entire history of the Everglades Coalition and our constituent organizations' work in the Everglades has shown us how difficult it is properly to anticipate the results of human action in the system, and how important it is to maintain the widest possible margin for the operation of natural processes.

Above any particular concerns we have with the plan and the process, we note that the Corps and others who have contributed their efforts now demonstrate a regard for systematic values, and propose systematic responses, more attuned to those natural

6. The U.S. Fish and Wildlife Service is the Federal agency with the responsibility to determine effects on species listed under the Endangered Species Act. They have concluded that the BRD Operation would jeopardize the continued existence of the snail kite, but that no other listed species would be as affected by any of the alternative plans of action. If new information becomes available that potentially could have bearing on these findings, reconsultation with the USFWS would be sought. During this process, coordination such as you suggest could be considered. Furthermore, the USFWS has requested a reconsultation under the Endangered Species Act addressing the entire C&SF Project. The Corps is planning to comply with this request.

processes, and less indicative of an urge to outsmart them. We are confident that the long view will show that tendency to serve the best interests of our region's ecology, its economy, and its society. We ardently hope that the development and disposition of this plan continues on a healthy course. If so, we think it may be an historic example for our conduct throughout the Everglades.

Sincerely,

Brien F. Culhane

Brien F. Culhane
Chairman

On behalf of:

The Wilderness Society
1,000 Friends of Florida
Defenders of Wildlife
Environmental Defense Fund
Florida Audubon Society
Florida Division, Izaak Walton League of America, Inc.
Friends of The Everglades
Tropical Audubon Society

Sikelli
68 St.
Ft. Lauderdale, Fl. 33331
October 31, 1990

Department of the Army
Jacksonville District
Corp of Engineers
P.O. Box 4970
Jacksonville, Fl. 32232-0019

Dear Sir:

I would like to make comments on the General Design Memorandum on Modified Water Delivery to the Everglades National Park.

The Everglades Co-Ordinating Council does not feel this project needs to be done at this time, there has not been enough information obtained on this project to show that it will have a great effect on the water delivery to the E.N.P., we feel we should wait until the present Law Suit filed by the U.S. Government on the Water Standard Act should be settled and then a new study should be made to look at the water delivery after that.

If the project goes forth there two major problems, (1) the quality of water which would be put into Conservation Area 3B, the other is the navigation problem it will cause in the L67 Canal. Let's discuss the
(1) 1st problem on the quality of water which will be put into Conservation Area 3B, at the present time the only water entering 3B is rain water, consequently this area is one of the only areas which is left in its natural state, free from the polution coming from your agriculture fields and urban areas. This area has survived under these conditions and has the best wildlife and bird population for any surrounding area, including the Park. The only way this water should be allowed to be put into this area, is it would meet the Water Quality Standards set by law.

The second problem is the navagation problem, according to this plan, you want to install weirs in the L-67 which will prevent boat traffic, this is rediculus, this does not need to be done, if you want to put
(2) water into 3B you can do so by using a couple of methods, (1) install culverts under the levee so that water can flow from 3A to 3B by natural flow. (2) Remove tha levee at certain points so you would have sheet flow across the canal banks. There is no need for weirs which would cause all kinds of problems.

Yours truly,
Freddy Fisikelli
Freddy Fisikelli
Everglades Co-ordinating Council

RESPONSES TO

Everglades Co-ordinating Council — Letter of October 31 1990

1. See response to comment #2 in F.A.D.E. letter (page F-4).
2. See response to comment #1 in F.A.D.E. letter (page F-4).

Florida Department of Environmental Regulation
Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400
Bob Martinez, Governor Dale Twachmann, Secretary John Shearer, Assistant Secretary

October 31, 1990

RECEIVED
NOV 1 1990
STATE CLEARINGHOUSE

Ms. Karen K. MacFarland
Director
State Clearinghouse
Office of the Governor
The Capitol
Tallahassee, Florida 32399-0001

Dear Ms. MacFarland:

RE: SAI #FL9008080208C, Modified Water Deliveries to Everglades National Park, Draft GDM and EIS

We appreciate the efforts by the Corps in the coordination process and development of the draft General Design Memorandum (GDM) for Modified Water Deliveries to Everglades National Park. We are pleased to see the progress made since the Governor's East Everglades Land Acquisition Task Force Report (October 1, 1988). The Report recommendations were swiftly transformed into the Everglades National Park Protection and Expansion Act (PL 101-229, December 13, 1989) and provided you the authority to expeditiously develop this GDM and upon its finalization, construct modifications to restore more natural hydrological conditions within the Park. Simultaneously, the South Florida Water Management District (SFWMD) has developed an Everglades Surface Water Improvement and Management (SWIM) Plan to restore more natural water quality and hydrological conditions throughout the Everglades system.

Our review of the draft GDM has considered each of the various project and operational alternatives described, the goals and recommendations of the Governor's Task Force, and compatibility of the Corps' recommended project with the SFWMD final draft Everglades SWIM Plan. Based upon these considerations, we offer the following comments:

1. The Corps' recommended redistribution structures and the adoption of a rain-driven delivery schedule will result in hydroperiod enhancement for thousands of acres of Northeast Shark River Slough and Water Conservation Area - 3B (WCA-3B), and improve the sheet flow to Shark River Slough west of the L-67 Extension by minimizing rapid variations in water depth. The provision of flood protection to the residential area is consistent with the recommendations of the Governor's Task Force. We encourage the construction and operation of these portions of the recommended project as soon as possible. However, construction designs for the S-345 and S-349 structures proposed for L-67A and L-67C have not sought to minimize wetland impacts, and should be reevaluated. Wetland resource management permits will be necessary for

RESPONSES TO

Florida Department of Environmental Regulation Letter of October 31, 1990

1. The construction of the S-345's and S-349's will impact the wetlands on which they are built. However, the Corps will insure that environmental disruption is minimal during construction of the structures. At this time, the S-349 structures are the most effective for providing a more natural distribution of water in WCA No. 3A, and at the same time maintaining other project purposes such as water supply.

Other alternatives were considered that would not directly impact wetlands. These are described in the GDM. It was determined that the proposed structures and appurtenant levees and canals would be the most effective means of restoring WCA No. 3B as a functioning component of the Everglades System.

implementation of the flood protection project for the residential area and for several of the structures proposed within the draft GDM.

2. Implementation of the SFWMD Everglades SWIM Plan will also restore the hydroperiod of thousands of acres of wetlands in the Everglades, including the northern portions of WCA-3A and the Holey Land. Additionally, thousands of acres of Nutrient Management Areas will be constructed, resulting in improved water quality discharged from the Everglades Agricultural Area into the WCAs. Unfortunately, the systems which will accomplish these beneficial improvements to the Everglades will also require additional water in a region which has recently had a limited water supply. The SFWMD is presently developing both a District-wide and a Lower East Coast Water Use Management Plan to help address these concerns.

(2)

We encourage the Corps to consider the water supply issues carefully in determining a final operational plan for the Modified Water Delivery to Everglades National Park. The SFWMD has expressed concerns about the Modified Rain-Driven Plan, particularly due to its additional water demands beyond those for the Basic Rain-Driven Plan. We request that you recognize the water quality improvements, substantial acreage of wetlands enhancement, and increasing demands for water supply resulting from the SFWMD Everglades SWIM Plan as you proceed in finalizing the GDM and determining the ultimate operational schedules.

3. Based on the information provided, we find this project to be consistent with our authorities in the Florida Coastal Management Program at this time. A reevaluation of the project will be conducted during the environmental documentation or permitting stage if required. Future consistency will be based in part on adequate consideration of comments offered in this and subsequent reviews.

If you should have any questions regarding our comments, please contact me. Thanks for your assistance in restoration and protection of the Everglades.

Sincerely,

Randall L. Armstrong, Director
Division of Water Management

RLA/blb/dpm

cc: Colonel Malson
Dale Twachtmann

2. The analysis and testing of the operating criteria will also consider water quality and wetlands enhancement produced by the SFWMD Everglades SWIM Plan. The proposed modifications in the GDM and the SWIM Plan should work towards the common goal of restoring the Everglades.

STATE OF FLORIDA

Office of the Governor

THE CAPITOL
TALLAHASSEE, FLORIDA 32399-0001

BOB MARTINEZ
GOVERNOR

October 31, 1990

Mr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District,
Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: Draft General Design Memorandum and Environmental Impact Statement - Modified Water Deliveries to Everglades National Park, Florida - Central and Southern Florida Project

SAI: FL9008080208C

Dear Mr. Salem:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 83-150, the Coastal Zone Management Act and the National Environmental Policy Act, has coordinated a review of the above referenced project.

Pursuant to Presidential Executive Order 12372, the project will be in accord with State plans, programs, procedures and objectives when consideration is given to and action taken on the enclosed comments and requirements of our reviewing agencies.

Please refer to the enclosed comments provided by the Game and Fresh Water Fish Commission (GFWFC), Department of Environmental Regulation (DER), Department of State (DOS), Department of Natural Resources (DNR) and South Florida Water Management District (SFWMD).

The federal agency did not provide a federal consistency determination for this project in accordance with 15 CFR 930, subpart C. However, the State has completed a review of the project information available at this time. Based on this information, the project at this stage is consistent with the Florida Coastal Management Program. Although the State does not object to the proposed work, we have identified several issues which must be resolved as the project progresses through later stages of planning, design and funding. As required by 15 CFR 930.34 and .37, at each major point of decision-making the federal agency is required to submit a consistency determination

for the State's review. The format and content of the determination are described in 15 CFR 930.34 - .39. The State's continued agreement with this project will be based, in part, on adequate reconciliation of previously identified concerns.

This letter reflects your compliance with Presidential Executive Order 12372.

Sincerely,

Karen K. MacFarland

Karen K. MacFarland, Director
State Clearinghouse

KKM/rt

Enclosure(s)

Response From: Department of Environmental Regulation
Department of Natural Resources
Department of State
Game and Fresh Water Fish Commission
South Florida Water Management District

cc: DER
DNR
DOS
GFWFC
SFWMD
Ted Hoehn

For projects circulated for evaluation of consistency with the FCMP, the process is slightly different. An additional review is not necessary as your plans, policies and objectives are, in large part, mandated by appropriate Florida statutory authority. However, for consistency review purposes, it is suggested that your comments in response to the attached document be expressed as follows.

Based on an analysis of the mandatory enforceable provisions and recommended policies of the core FCMP statutes and implementing rules which your agency administers, the proposed activity is:

- Consistent
- Not Consistent. Objections to an activity must describe how the proposed project is inconsistent with the specific provisions included in the FCMP and alternatives if any, which if adopted, would allow the activity to be consistent.
- Not consistent due to failure to provide sufficient information to assess the consistency of the activity. Objections or findings of inconsistency based on insufficient information must describe the nature of information is necessary to determine consistency.

Should you need additional information from the applicant for IC&RP purposes or to evaluate the consistency of the project with the FCMP, please contact the applicant for the required information and notify this office by the due date. The State Clearinghouse will promptly inform the applicant that a project review cannot be completed until such information is provided to reviewers. Should a conference be necessary, please contact this office as soon as possible. Timely response is essential in order to preserve the state's rights in both IC&RP and CZMA Consistency proceedings.

Please check the appropriate box below, provide any comments on your agency's stationary and return to the State Clearinghouse by the due date. In both telephone conversation and written correspondence, please refer to the State Application Identifier (SAI) number.

Enclosure

****

	E.O. 12372	FEDERAL CONSISTENCY
TO: Director State Clearinghouse Office of Planning and Budgeting Executive Office of the Governor The Capitol Tallahassee, Florida 32399-0001 (904) 488-8114	☐ NO COMMENT ☑ COMMENTS ATTACHED	☑ CONSISTENT (COMMENTS ATTACHED) ☐ NOT CONSISTENT (COMMENTS ATTACHED)

FROM: DOT

SAI#: FL9008 08 0208 C

DIVISION/BUREAU: Environment

REVIEWER: C. L. Irwin

DATE: 11/2/90

09/88/0283I

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REPLY TO: Sarasota

HAND DELIVERED

October 31, 1990

Colonel Bruce Malson
The District Engineer
U.S. Army Corps of Engineers
Jacksonville District
400 West Bay Street
Jacksonville, Florida 32202

Re: **Comments To: Central and Southern Florida Project for Flood Control and Other Purposes, Part I, Agricultural and Conservation Areas Supplement 54 - Draft General Design Memorandum and Environmental Impact Statement on Modified Water Deliveries to Everglades National Park, Florida**

Dear Colonel Malson:

This letter is written on behalf of Okeelanta Corporation ("Okeelanta") and South Bay Growers, Inc. ("South Bay"), clients of this office. Okeelanta and South Bay own property and conduct farming activities in the Everglades Agricultural Area ("EAA"). As noted in the oral comments presented at the October 22, 1990 public hearing, South Bay and Okeelanta are concerned about the adequacy and scope of the above-referenced proposal by the U.S. Army Corps of Engineers (the "Corps") to alter a portion of the Central And Southern Florida Flood Control Project (the "Project"), which serves the entire region, including the EAA. Like others in the Project area, Okeelanta and South Bay rely on the continued, coordinated and reasonable operation of this federal Project for the flood control and water supply essential to the protection of their property and agricultural operations.

Based on review of the draft General Design Memorandum ("GDM") and Environmental Impact Statement ("EIS") with regard to proposed changes in certain components of the Project, and after hearing the presentations and public comments at the October 22, 1990 hearing, Okeelanta and South Bay question the scope and adequacy of the proposal. The proposed alterations to the Project appear to give inappropriately heightened priority to narrow and unsubstantiated

environmental benefits sought in one part of this regional Project without adequate review of potentially detrimental impacts regionwide, or alternatives which would mitigate or prevent these impacts.

South Bay and Okeelanta have identified three primary areas of concern:

(1) The proposal fails to address the long-term regional impacts on water quantity and water supply to other users of the Project outside the study area. Specifically, there is no assessment of the effect of diverting additional water needed to support the Modified Rain Driven ("MRD") Plan, as proposed, on the water needs and rights of other users of the Project. (1)

(2) The water quality issues as identified in the GDM and EIS are unsubstantiated and inject irrelevant issues and purposes outside the Congressionally authorized purpose of restoring a more natural hydroperiod to Everglades National Park ("ENP"). (2)

(3) The draft EIS is too limited in its scope and constitutes inappropriate segmentation of changes to the federal Project to avoid or prevent adequate review of the project-wide impacts resulting from the proposal. The MRD proposal also represents an illegal attempt to retrofit the federal Project in a manner and for purposes outside the Congressional authorization to improve water deliveries to ENP, in violation of the National Environmental Policy Act of 1969 ("NEPA"), 42 U.S.C. § 4321 et seq., and its implementing regulations; Public Laws 98-181, and 101-229, and the Federal Flood Control Act, 33 U.S.C. § 701 et seq. (3)

I.
INTRODUCTION

1. The Basic Rain Driven Model.

The original intent of the GDM, as authorized by Congress in Public Laws 98-181 and 101-229, was to restore the "natural hydrological conditions" of ENP. At present, deliveries to ENP are largely via the L-67 Canal and are skewed to the western "Chimney" side of ENP through the "12" structures. As a result, the north end of WCA-3A is too dry, the south end of WCA-3A is too wet, and the location, timing and volume of flow to ENP are very different than occurred under historical natural conditions.

The original GDM Proposal, known as the Basic Rain Driven Model, or BRD, would have blocked the L-67 Canal in Water

RESPONSES TO

Peeples, Earl & Blank — Letter of October 31, 1990

1. The purpose of the model simulations is to compare the base condition against all other alternatives. Fourteen years (1969-1982) were simulated to assess the long-range impact of the various plans on water deliveries to Everglades National Park (ENP) as well as other areas within the model boundary. The model includes Lake Okeechobee, the Everglades Agricultural Area, the Water Conservation Areas (WCA's), ENP, portions of C-111, and other areas. Appendix E addresses water supply issues in each of these regions. For example, storage for Lake Okeechobee, WCA's, and total system can be found in this appendix. For the base condition vs. the recommended plan these data are available in figures E-8 through E-163.

2. The authorizing legislation (PL 101-229) mandated that the C&SF project be modified to improve water deliveries to the ENP and to take steps "to restore the Park's natural hydrologic conditions". Part of restoration of the natural hydrologic condition is improving the quality of the water delivered to the Park. Under the MRD Plan, southerly flow to the S-12's is predominantly sheet flow in the wet season and canal flow during the dry season. During the wet season water will be of higher quality because of the assimilating capacity of the marsh vegetation. During dry spells, the higher nutrient canal water at the S-12's would not be delivered to the Park until rain events had broken up the dry spell, as was the case under the minimum delivery schedule. In some circumstances, rainfall-induced flow from the adjacent marsh would dilute the nutrient concentration in the canal before water deliveries are made through the S-12's.

3. Preservation of fish and wildlife resources has been a purpose of the C&SF Project since it was authorized in 1948 (PL 858-80). The MRD is fully consistent with the authorization provided in PL 101-229. All potential impacts of this project are addressed in the EIS.

Conservation Area ("WCA") 3A with gates, and forced water to flow west and then south via sheet flow across WCA-3A. New culverts would have allowed flow to the east into WCA-3B and then south via sheet flow. Water would be discharged from the south end of WCA-3B via new culverts to flow under Tamiami Trail and then into Northeast Shark River Slough ("NESRS"). Under the BRD proposal, 55% of ENP deliveries would go via NESRS and 45% via the "12" structures. The L-67 EXT Canal located south of Tamiami Trail would be removed.

The BRD Plan described above has been under development for approximately 5 years. Only recently, during the final design and analysis process, has the United States Fish and Wildlife Service ("USF&WS") determined that the present pool of water located at the southeast corner of WCA-3A, although not "natural", has created an excellent habitat for the endangered Everglades snail kite. The USF&WS maintains that the proposed BRD Plan will jeopardize the Everglades snail kite now established in the artificially created habitat, in violation of The Endangered Species Act of 1973, 16 U.S.C. § 1531 et seq. For that reason, the Corps is now proposing an altered version of the original concept for restoring more natural hydroperiod to the Everglades. The new Plan, the so-called Modified Rain Driven Plan, poses new, regional impacts on the human environment, which impacts have not been adequately assessed.

2. **The Modified Rain Driven Plan**

To accommodate the objectives of the USF&WS to prevent the loss of the new habitat, a Modified Rain Driven ("MRD") Plan was developed. The MRD Plan is similar to the BRD Plan, but differs greatly in operation and impact. Instead of relying on waters naturally available in the area affected by the GDM and EIS, the MRD Plan calls for moving an unspecified volume of extra water from Lake Okeechobee to the south end of WCA-3A via the L-67 Canal. This extra water would be used to maintain the present artificial pool of ponded water which exists in the south end of WCA-3A. The MRD Plan would therefore maintain the same man-induced alterations to the area's hydrological conditions the BRD proposal was intended to correct. The purpose of the Congressional mandate would be therefore largely abrogated.

None of the commenting agencies or environmental organizations have expressed strong support for the MRD Plan over the BRD Plan because the original BRD Plan is more "natural." The agencies have apparently agreed to work together to develop other operational alternatives, despite the incomplete review of impacts outside the

limited study area, and to proceed to build the structural features called for by the original BRD Plan. These structures are projected to cost approximately $72,000,000. If the agencies cannot come up with a better operational plan which addresses the conflicting habitat and hydrologic goals impacted by the BRD, the MRD Plan apparently represents the fallback plan as an improvement over present conditions. Both plans, as presented in the GDM and the EIS, raise significant concern both as to their precedential impact for future piecemeal changes to the regional Project and the ultimate effect of such changes on the region as a whole.

II.
DISCUSSION OF THE QUESTIONS PRESENTED BY THE PROPOSAL

1. The GDM and EIS Do Not Address Regional Water Supply Impacts Posed By the Proposal.

The BRD Plan developed by the Corps over the last five years appears to meet the Congressionally established objectives of improving timing, location and volume of flows throughout WCA-3A and WCA-3B to ENP. The MRD Plan represents a hasty alteration of operational aspects of the BRD Plan to maintain a small area of artificially created deep water Snail Kite habitat in the southeast corner of WCA-3A. The MRD Plan will promote unnatural conditions in large areas of WCA-3A. This is inconsistent with the goals and mandate to restore natural hydroperiod in the area. In order to maintain this artificial ponding for habitat reasons, the MRD Plan will require the use of between 100,000 and 115,000 acre feet of water not required by the BRD and proposes to divert this additional water from Project components presently serving urban, agricultural and other users in other parts of the Project area.

(4)

The amount of water proposed to be diverted under the MRD to maintain the artificial habitat is enough water to supply the annual needs of approximately 900,000 people each using 100 gallons per day. Thus, while the BRD Plan attempts to improve present conditions to a more natural, balanced hydroperiod, the MRD Plan proposes artificial manipulation of the hydroperiod in the study area, and will impact other areas of the Project outside the scope of the GDM and EIS. In order to promote isolated wildlife considerations, the MRD Plan will reduce the available water supply to other co-equal users of the Project.

South Bay and Okeelanta submit that alternatives exist which would provide habitat elsewhere in the WCA's which have not been adequately addressed in the GDM or EIS. It is not necessary to "rob Peter to pay Paul." Water should not be taken from a

4. The structural modifications presented in the MRD and the BRD are the same. However, the operating criteria modelled for these plans are different. One major difference is the MRD modelling did not include the S-349 structures. With these structures the discharges from the S-8 structures to WCA No. 3A will be much lower. This and other issues would be re-evaluated during studies subsequent to the GDM. In accordance with PL 101-229, a periodic evaluation of the operating criteria will be conducted after the project is fully implemented. Thorough analysis and testing studies will be made as necessary to establish an optimum water control plan within prevailing constraints. Therefore, the deficiencies of the MRD will be addressed during evaluation of the operating criteria. At this time, the MRD is proposed since it meets the constraints and will allow the project features to be constructed. Additional description of water supply impacts has been added to the GDM (see Main Report).

component of the Project, Lake Okeechobee, already stressed by drought conditions, to maintain an environmental benefit only recently, and not naturally, existing in another part of the Project. The GDM fails to address the long-term regional effects of this MRD water use on other parts of the system and on other users with equal rights to rely on the water resources of the Project.

2. **The Water Quality Issues and Facts Presented Are Unsubstantiated and Outside the Scope of the Congressionally Authorized Action.** (5)

The concept of modifying the structural design of the Project to provide greater operational flexibility is a good one. The Congressionally established goal of providing improved timing, distribution and volume of flows throughout the WCA's and ENP is also desirable. The assertions in the GDM and EIS, however, that there are water quality problems existing or to be addressed by the proposed alteration to the Project are without factual support.

There is no evidence of a water quality link between the EAA and ENP - past, present or future. The numerous speculative assertions in the GDM and EIS as to "threats" to ENP due to alleged water quality impacts attributed, without basis, to other users of the Project including the farmers in the EAA only divert attention away from the real problem in ENP. The Corps' valid mission is to solve the hydroperiod problems threatening ENP without causing unacceptable water supply and flood control impacts in other parts of the region. Furthermore, the GDM and EIS neglect to address other sources of possible water quality problems. The GDM and EIS process should not be used as a forum to speculate about or promote unproven theories about future water quality problems.

During drought conditions, there is competition for water between agricultural, urban and environmental interests. During flood periods there is competition between these same interests for drainage and flood control, and in many cases in the past it has been necessary to divert surplus quantities of water from the WCA's to ENP. It is generally agreed that these unnatural fluctuations in hydroperiod have been a primary cause of the changed conditions in ENP. The increase of operational flexibility in the system is justified by known and obvious water quantity considerations. The assertions as to water quality impacts and conclusions are much less certain and have not been documented.

The National Park Service has expressed concern that continued discharges of "elevated" nutrient concentrations into the WCA's

5. The Corps disagrees that there is "no evidence of a water quality link between the EAA and ENP". The evidence for this is overwhelming and well known to the scientific community.

ultimately could impact vegetation communities in ENP, but average nutrient concentrations in water discharged from the federally owned Project structures to ENP are well below those at which such impacts allegedly occurred. ENP receives actual discharge concentrations which average out at levels similar to marsh background water quality. To date no documentation has been presented to suggest that an impact has occurred due to changes in water quality, much less any water quality changes related to activities in the EAA, yet these "changes" are repeatedly asserted as if they were conclusively established. See, e.g. GDM at p. 14 ¶ 18, p. 20 ¶ 34 and EIS at p. 10 ¶ 3.05.

Further evidence of the dubious nature of the assertions of water quality problems and their sources is found in the Corps' own documents. In letters dated July 13, 1990, from Robert S. Chandler, Superintendent of ENP, to Colonel Bruce Malson and to Mr. Billy Cypress, Chairman of the Miccosukee Indian Tribe, regarding certain permits sought by the Miccosukees for residential construction, Superintendent Chandler notes the water quality problems in ENP associated with the water and sewage disposal activities of the Miccosukees. (Copies of the July 13, 1990 letters are attached hereto.) The implication of Superintendent Chandler's letters is that tribal sanitary and septic facilities are presently inadequate. If there are changes to the north end of ENP related to nutrients, these changes are more likely related to human activities along U.S. Highway 41, the northern ENP boundary, than to agricultural activities in the EAA.

Okeelanta and South Bay object to the inclusion of the speculative water quality assertions in the GDM and EIS which attribute any environmental changes in ENP to agricultural activities in the EAA. Any problems in ENP are the result of hydroperiod fluctuations caused by the operation of the Project. It is misleading and inappropriate to include in these factual documents unsubstantiated speculation as to any environmental impacts in ENP from activities in the EAA. It is requested that the water quality discussions and references be deleted from the documents to insure no improper reliance on conjecture, instead of reliance on fact in the final decision regarding the proposal.

III.
LEGAL DEFECTS

1. **The Proposal Constitutes Illegal "Segmentation" of Regional Impacts to Avoid Regional, Project-wide Review.**

The study and impact review has been limited to a narrow study area, yet the impacts of the proposed action will be regional. This type of "segmentation" violates NEPA. The current, narrow proposal fails to address the admitted synergistic, regionwide effects of the proposed action with other recent past actions and pending actions to alter other components of the regional Project. The pending "SWIM" process, and the water supply and use planning and rulemaking, now ongoing before the Project's local sponsor, the South Florida Water Management District, will also make radical changes in other parts of the Project which will affect the study area. These proposals, however, have not been taken into account.

A major impetus for change in the Project has been the permanent implementation of the so-called "Interim Action Plan" ("IAP"), which altered the operation of Lake Okeechobee and is the alleged triggering action for significant environmental and other impacts Project-wide. The IAP was initiated and implemented without any comprehensive review of its impact, and its long-term impacts now may be evident. One alternative which has not been reviewed, but which would be within the expanded scope of the MRD proposal, would be to stop the IAP and return Lake Okeechobee to its prior schedule of operation and levels. Continued tinkering on a piecemeal basis with only small parts of the regional Project will only result in the same kind of future rippling impacts assertedly generated by the IAP. A comprehensive, regional EIS should be performed; the current GDM and EIS are inadequate to address the regional impact the action poses alone and cumulatively with other past and future changes to the Project.

2. **The Proposal Constitutes Unauthorized Retrofitting of a Federal Flood Control Project.**

The MRD requires diversion of waters from Lake Okeechobee, thereby altering the water supply available to others in the region. The purpose of the diversion is to enhance artificially created environmental benefits to the detriment of the water supply and flood control functions served by the Project. There is no Congressional authority to alter the Project for these purposes. Insofar as the GDM and EIS propose changes to the Project's structure, operation and purposes to promote environmental purposes

6. The IAP (now the LOOP) was in place more than 5 years before this project was initiated. The IAP was implemented by SFWMD within the operating criteria prescribed by the Corps. Shortly after this project was initiated, SFWMD adopted the IAP as a long term operational plan and it was renamed the Lake Okeechobee Operating Permit (LOOP). No Federal action was required. Therefore, for purposes of this project, the LOOP was appropriately considered a component of the Base Condition. Removal of the LOOP was not considered because it would not be consistent with the goal of restoring natural hydrologic conditions. More runoff from the Everglades basin would be diverted northward rather than flowing south to the Everglades if the LOOP was removed.

7. PL 101-229 authorizes the Secretary of the Army to modify the C&SF project to improve water deliveries to ENP. Diversion of waters from Lake Okeechobee to restore the natural hydrologic conditions of the Park is part of the necessary modifications of the C&SF Project. Diversion of water with the purpose of protecting endangered species complies with The Endangered Species Act as Amended by PL 97-304.

over the other purposes established by Congress, the actions are inappropriate and invalid.

3. The MRD Plan Is Inconsistent With Congressional Direction.

As noted above, the Congressionally established purpose of the alteration of the Project is to restore natural hydrologic conditions to ENP, insofar as is possible without violating the rights of others in the study area. P.L. 98-181 and 101-229. Alteration of the Project in and out of the study area to serve wildlife habitat needs and to maintain artificial hydroperiods is inconsistent with this Congressional mandate. The legality of the MRD proposal is questionable and the MRD Plan is inconsistent with the Congressional direction to restore natural hydrological conditions to the ENP area. (8)

IV.
CONCLUSION

South Bay and Okeelanta object to the proposed action because of its serious factual and legal shortcomings. It is respectfully requested that the Corps expand the scope of the review to address the comprehensive, regional impacts posed by the proposal, or in the alternative, take no action until full regional impact review and alternative assessment on the MRD can be accomplished.

On behalf of South Bay and Okeelanta, we appreciate the opportunity to comment on the GDM and EIS which describes modified water delivers to ENP. If you have any questions or need additional information, please feel free to contact me.

Sincerely,

PEEPLES, EARL & BLANK, P.A.

Judith S. Kavanaugh

Judith S. Kavanaugh
For The Firm

JSK/mhw
Encl.
cc: Client Copy
Paul W. Larsen

8. The protection of Critical Habitat for endangered species is required by the Endangered Species Act of 1973 and amendments. The MRD Plan was designed to minimize impacts to designated Critical Habitat for the snail kite while still preserving, the project objectives. P.L. 101-229 promotes the construction of C&SF Project modifications which will produce environmental benefits to the Everglades ecosystem as a whole and to the Park in particular, while recognizing the interdependence of the many segments of Florida's historic Everglades.

STATE OF FLC
DEPARTMENT OF NATURAL RESOURCES

Marjory Stoneman Douglas Building • 3900 Commonwealth Boulevard • Tallahassee, Florida 32399
Tom Gardner, Executive Director

November 1, 1990

RECEIVED
NOV 1 1990
STATE CLEARINGHOUSE

Ms. Karen MacFarland, Director
State Clearinghouse
Office of Planning and Budgeting
Executive Office of the Governor
The Capitol
Tallahassee, Florida 32399-0001

Dear Ms. MacFarland:

SAI No. FL9008080208C, USACE-Jacksonville
GDM, Modified Water Delivery to Everglades Nat. Park

The Department has reviewed the above referenced project. The proposed action is an attempt to restore the natual hydrologic conditions within Everglades natioinal Park through structural modifications and an operating plan. The Department supports the goals of this project. We are especially supportive of the restoration of flows across the Everglades into Florida Bay and encourage the monitoring of Florida Bay to assure that the restoration is working properly as time progresses. Another area that has been of concern is the flow of water through Canal 111 into Barnes Sound. The proposal does not expressely state that a reduction in the potential to have to make large discharges through C-111 will result, however, we would appreciate knowing if that is an achievable result through this project. Water quality issues should be carefully addressed throughout the continuation of this project. We look forward to continuing to work with the Corps through the continuation of this project. We find the project to be consistent based upon the information provided at this time.

Sincerely,

David W. Arnold

David W. Arnold
Senior Management Analyst

cc: Grant Gelhardt
Pam McVety
A. J. Salem

Administration: Bob Martinez, Governor
Beaches and Shores: Jim Smith, Secretary of State
Law Enforcement: Bob Butterworth, Attorney General
Marine Resources: Gerald Lewis, State Comptroller
Recreation and Parks: Tom Gallagher, State Treasurer
Resource Management: Doyle Conner, Commissioner of Agriculture
State Lands: Betty Castor, Commissioner of Education

RESPONSES TO

Florida Department of Natural Resources — Letter of November 1, 1990

1. Currently, the Corps of Engineers is studying the C-111 basin. This study will include the impacts of the Modified Water Deliveries to ENP and will make the appropriate recommendations on reducing large discharges to enhance the environment in the C-111 Basin.

2. See response to comment #2 of F.A.O.E. letter (page F-4).

FOREIGN AFFAIRS COMMITTEE
CHAIRMAN

ARMS CONTROL, INTERNATIONAL
SECURITY AND SCIENCE SUBCOMMITTEE
CHAIRMAN

SELECT COMMITTEE ON NARCOTICS
ABUSE AND CONTROL
MEMBER

Congress of the United States
House of Representatives
Washington, DC 20515

ADMINISTRATIVE ASSISTANT

COMMISSION ON SECURITY AND
COOPERATION IN EUROPE
MEMBER

NORTH ATLANTIC ASSEMBLY
CHAIRMAN
HOUSE DELEGATION

CANADA—UNITED STATES
INTERPARLIAMENTARY GROUP
MEMBER U.S. DELEGATION

November 2, 1990

Colonel Bruce Malson
District Engineer
Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32201

Dear Colonel Malson:

Enclosed, for your information, is correspondence I have received from one of my constituents regarding the GDM on Modified Water Deliveries to Everglades National Park.

I would appreciate your including Mr. Crum's comments in the official record on the GDM and giving the points he raises every possible consideration prior to issuing a final GDM on this project.

Sincerely,

DANTE B. FASCELL
Member of Congress

DBF:BB
Enclosure

RECEIVED
90 OCT 29 PM 2:23
DISTRICT OFFICE
CONG. DANTE B. FASCELL

HENRY G. CRUM
27130 SW 121ST CT
NARANJA, FL 33032
(305-257-5150)

The Honorable Dante B. Fascell
7935 S.W 104 St
Suite 220
Miami, FL 33156

25 Oct 1990

Dear Representative Fascell,

My name is Henry G. Crum, and I live at the above address. I am retired Air Force and presently work in the Civil Service system on Homestead AFB. I never in my life imagined that I would ever write to a Congressman or Senator, but I believe that I have to go on record with my opposition and possibly offer some alternatives to a big problem.

Attached is an article from the Miami Herald that was printed 28 Oct 1990. I was one of the 150 fresh water fishermen at this meeting representing the Military Bass Angler Association of South Florida, of which I am the Director with a membership from West Palm Beach to Key West. We are only part of a national organization.

First of all, I want to express my surprise that there was not a single elected official at this public hearing. I knew you are all up in the capital trying to fix the Federal Budget, but there wasn't even any spokesman there for the government. We are not only talking about over 80,000 votes in this matter, but also about over 72 million dollars of tax payers money. I think someone should've been there.

A lot of the discussion in opposition of the project was on the recreational use issue of L-67, which is important. The South Florida Water Management people have managed to close nearly every ramp in Dade county by filling them in with dirt or placing locked gates across them to prevent public use. L-67 was our last major water source in Dade county with public access and now they are closing the waters off. This will make Lake Okeechobee the next closest large body of water for fresh water use, which is a 3 hour drive. Hardly worth it for recreational use. If you do look into this, would you please find out why ramps are being closed and if they could open some of them back up. I would be glad to list where these ramps are if you want.

As can be seen by the article, and I am sure you already are aware of, the Army Corps of Engineers plan on building three dams across the canal and open up canals to divert the sheet flow of water from area 3A to 3B of the everglades to restore 3B to its' natural condition at a cost of 72 million dollars. I am all for saving the everglades and the environment and endangered species just as much as anyone else, but I don't think anybody really thought this out and looked at other alternatives, not only for recreational reasons but others.

(1) First, as you well know, we have had a water shortage for the past few years to the point of being in draught conditions and had to restrict water usage in South Florida. Lake Okeechobee was at an all time low, and still is not up to its' normal level. Obviously, with lack of rain, areas dry up. If they re-direct the

RESPONSES TO

Hon. Dante B. Fascell (Mr. Henry Crum) Letter of November 2, 1990

1. Under the proposed plan, Water Conservation Area No. 3B (WCA No. 3B) would be used to convey water to Northeast Shark River Slough. Inflows to WCA No. 3B would be closely matched to outflows from the area. Therefore, no significant changes to storage are expected in this area.

water as they plan to this BBW dry area to restore it to its' natural wetland condition, and next year or even five years from now, we have our regular rainy season return, this area will virtually be flooded, endangering the wild life and the environment on the other extreme end. What will it cost the tax payers then, to undo the dams? 100 million dollars?

Secondly, the plan is for this water that is being re-directed to come from Lake Okeechobee, that supplies this sheet flow. As I said, the Lake is low now That is South Florida' water supply. We would only be hurting ourselves in future years to this. We restricted water this year, next year we will have to do the same and eventually may not even have water this far south of the lake. This must be considered before allowing this to happened.

Third, there are other alternatives that could be used to re-direct the water that would cost less I believe and also make it a controllable project. If the Corps would install a flood control type gate (one that can be opened and closed when necessary) at the North Eastern end of L-67-C, which flows through area 3B, this would solve the problem of flooding and allow L-67 to remain open for navigation. If water is needed in 3B, just open the lock, if the lake starts dropping to dangerously low levels, close the gate. If not enough water would flow through the gate, a pump station could be there to increase the amount of water needed. I believe this could be done cheaper than 72 million, but if not, it sure has to be cheaper than the building of the dams and then five years from now paying to take them out. No one at the meeting didn't answer questions, or maybe they didn't know, but I think this needs to a possible avenue. These are the days when everyone is looking at cutting the federr. budget, and this is one federal project I believe someone needs to take a stand against.

(2)

One other problem that I would like to point out that also needs to be checked. It is public knowledge that there is a high level of mercury in the waters of L-67 Why should this water be dumped into a almost pure environment and do the same poisoning there? Are we trying to kill the everglades. We know this poisoning comes from upstate from the sugar cane growers and their runoffs from the crops. If we divert this water to 3B, we will just kill off another area.

(3)

There were other alternatives proposed from both sides. None of the Corps really were acceptable for various reasons that I could go into if you would contact me. I'm sure you could get a transcript of the hearing for your review.

I realize I have just taken a lot of your time, but I felt I had to say something. If you would like, I would gladly taker you out in my boat to the areas we are talking about, and you can see for yourself what the area looks like, or if you want feel free to call for more details. If you do investigate, please let me know results, especially interested in the ramp issue also.

Sincerely,

2. The proposed Modified-Rain Driven (MRD) Plan will mimic nature. As expected during wet years, there will be times where water is higher than others. However, the MRD is within the authority and purposes of the C&SF project. The MRD will also limit the amount of water delivered during dry periods, thus sharing adversity during dry conditions. One objective of the proposed project is to provide a more natural distribution of water in WCA No. 3A. The purpose of S-349 structures is to reduce southward canal flow through WCA No. 3A; thereby inducing overland flow through the marsh and providing a more natural distribution of water in the area. During the wet season more water would be held in the northern marshes of WCA No. 3A. The structures would also produce higher water levels upstream of each of the S-345 structures thus increasing the discharge capacity into WCA No. 3B. For water supply demands in the ENP-South Dade County Conveyance System, the structures would be opened and water supply deliveries could be passed down the L-67A borrow canal to S-333. Your proposed plan would not address the objectives for WCA No. 3A. As a result of public input, the proposed project would be modified to include by-pass channels around S-349 structures and tie-back levees. This will permit recreational navigation while allowing the diversion of water necessary to meet the project purposes.

3. The origin of unusual levels of mercury in the L-67A borrow canal is not known, however, it is believed to come from natural sources. Due to this factor and others, water quality criteria would be considered before water is delivered to WCA 3B.

Fishermen oppose L-67 dam

By JIM HARDIE
Special to The Herald

About 150 fresh water anglers went to a U.S. Army Corps of Engineers public hearing Monday night fully expecting a battle equal to hooking a 10-pound bass. As disagreements go, the anglers ended up with a one-pound throw-back.

In all the planning — including construction of three dams — to try to restore a sheet flow of water across the east Everglades into Shark Slough in Everglades National Park, a detail was over-looked. "We never took the fishermen into consideration," admitted Colonel Bruce Malson of Jacksonville, District Engineer for the Corps of Engineers.

The remarkably peaceful hearing was at Dade County Commission chambers.

"There are 80,540 licensed fresh water fishermen in Dade, Broward and Palm Beach Counties, and to almost all of them, L-67 Canal is the most important bass fishing area," said Tom Cunard, president of Fishermen Against Destruction of the Environment (FADE). "If you follow through with your plans to build three dams across L-67, it will virtually remove that area as a major source of recreation."

Col. Malson explained that public comment will be accepted until the end of October, then a plan will go from his office to regional headquarters in Atlanta, national headquarters in Washington and finally must be approved by Congress.

F-110

National Audubon Society
SOUTHEAST REGIONAL OFFICE
928 N. MONROE STREET, TALLAHASSEE, FLORIDA 32303 (904) 222 2473

November 16, 1990

Mr. A.J. Salem
Chief of the Planning Division
U.S. Army Corps of Engineers
PO Box 4970
Jacksonville, FL 32232

Dear Mr. Salem:

Recently, the Everglades Coalition sent in comments to the Corps of Engineers Draft General Design Memorandum and Impact Statement of Modified Water Delivery to Everglades National Park. The National Audubon Society reviewed the GDM and our comments and concerns are reflected in the Everglades Coalition statement.

The National Audubon Society concurs with the Coalition's statement and wishes to have its' name added to the list of organizations supporting the Everglades Coalition statement. The National Audubon Society was inadvertently left off the list of organizations supporting the Coalition statement when it was originally sent to your office.

Thank you for your assistance.

Sincerely,

Larry Thompson

Larry Thompson
Regional Vice President

LT:tj

PEEPLES, EARL & BLANK
PROFESSIONAL ASSOCIATION
ATTORNEYS AT LAW

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KATHLEEN D. KIRWIN
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DAWN M. MEYERS
DOUGLAS M. WICHOFF
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MARIAN GARCIA

GRANT PEEPLES
OF COUNSEL

ONE BISCAYNE TOWER
TWO SOUTH BISCAYNE BLVD.
MIAMI, FLORIDA
SUITE 888
SARASOTA, FLORIDA

REPLY TO: Sarasota

December 13, 1990

Colonel Bruce Malson
The District Engineer
U.S. Army Corps of Engineers
Jacksonville District
400 West Bay Street
Jacksonville, Florida 32202

Re: Comments To: Central and Southern Florida Project for Flood Control and Other Purposes, Part I, Agricultural and Conservation Areas Supplement 54 - Draft General Design Memorandum and Environmental Impact Statement on Modified Water Deliveries to Everglades National Park, Florida

Dear Colonel Malson:

By letter dated October 31, 1990, this firm submitted comments on the above referenced matter on behalf of Okeelanta Corporation and South Bay Growers, Inc. Since that time, additional information has become available which needs to be addressed in the EIS/GDM.

(1) It now appears that federal agencies, other than the Corps, are demanding that the Project meet a standard of 8 Parts Per Billion total phosphorus at the point it flows into the Park. This appears impractical, if not impossible, under any of the presently proposed modifications.[1] An alternative plan contemplating a standard of 8 PPB of phosphorus and the modifications necessary to achieve such level, assuming it were possible, was not considered or addressed in any way in the current GDM or EIS.

(2) It is respectfully requested that the Corps withdraw the current GDM and draft EIS and, pursuant to the procedures established under NEPA and its implementing regulations, initiate a comprehensive EIS and overall GDM on the Central and Southern Florida Flood Control Project to ensure that the protection of Everglades National Park is balanced with flood control, water supply, and other needs of the region. The GDM and EIS should evaluate this issue as well as the feasibility and practicability of such a proposed standard.

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[1] This is especially true with reference to the East Everglades and development in the Park adjacent to the Tamiami Trail.

RESPONSES TO

Peeples, Earl & Blank — Letter of December 13, 1990

1. The Corps has agreed to do further analysis of the water quality issues while pursuing the construction of the project features. The proposed project features would provide the greatest flexibility for the purposes of restoring the natural hydrologic conditions to the Park while ensuring that the purposes of flood control, water supply, and water quality are also achieved. This project is addressing the resolution of water quantity issues in the Everglades. It will not adversely impact water quality. The acceptable levels of phosphorous and nitrogen are currently being developed through the State's SWIM Process and U.S. vs. SFWMD. Final concentrations have not been identified. This project will be consistent with the final water quality standards that are developed.

2. Preparation of the GDM was made in response to legislative action (PL 101-229) concerning the restoration of the Park. A comprehensive EIS for the C&SF project is not authorized under this legislation, therefore, the Corps cannot conduct a study that lacks authorization and funding.

We also believe the Corps may want to consider the adverse national policy impacts on the Central and Southern Florida Flood Control Project and other Corps flood control projects, if such projects are required to meet state water quality standards or requirements such as the 8 PPB phosphorus standard now being aggressively asserted by certain federal agencies as being applicable to the Corps' flood control projects.

Failure to consider the impractical new 8 PPB phosphorus standard proposed by another federal agency is one more example of the historical segmentation of the Project and the resultant absence of comprehensive environmental impact analysis. This has resulted in cumulative and synergistic adverse impacts throughout the subject area, to the detriment of the human environment. Continued micromanagement of this federal Project to address narrow local single issue impacts, or the whims of particular federal agencies without balancing the effect on the region as a whole, violates the spirit and letter of federal law including the National Environmental Protection Agency ("NEPA") and the Flood Control Act.

(3) It is respectfully requested that the Corps, as lead agency, take whatever steps are necessary to ensure that a comprehensive, Project-wide environmental impact study be performed. This study should assess all alternatives for the future management of the Project to protect and balance the competing needs and benefits of the region it serves. The degree of federal participation must also be addressed.

Your consideration of these comments and this request for NEPA action is sincerely appreciated.

Very truly yours,

PEEPLES, EARL & BLANK, P.A.

Judith S. Kavanaugh

Judith S. Kavanaugh
For the Firm

JSK\rkc

3. Preparation of the GDM was made in response to legislative action (PL 101-229) concerning the restoration of ENP. A comprehensive EIS for the C&SF project is not authorized under this legislation, therefore, the Corps cannot conduct a study that lacks authorization and funding. There is no requirement or funding under federal law for a "comprehensive Project-wide" EIS.

RESEARCH DEPARTMENT • 115 INDIAN MOUND TRAIL • TAVERNIER, FL 33070 • (305) 852-5092

4 January 1991

Dr. Jonathan D. Moulding
U.S. Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232

Dear Dr. Moulding:

Since our letter of 24 September 1990 commenting on the *General Design Memorandum on Modified Water Deliveries to the Everglades National Park*, we have followed the progress of the GDM through the comment process. We have met with the scientific staff of the National Park and have traveled to Washington to meet with representatives of the Fish and Wildlife Service. The lack of agreement between these two agencies has resulted in an unfortunate situation concerning the endangered species of the Everglades. National Audubon has always been intimately interested in and involved with both endangered species and the Everglades. For this reason, the Society has felt it necessary to comment on the GDM at greater length and with more detailed documentation. We feel that the future health of the National Park and, indeed, of south Florida depends to a great degree on the actions taken by the Corps and, with this in mind, we appreciate the opportunity to supplement our original letter with the attached comments.

Sincerely,

Alexander Sprunt IV
Vice President for Special Projects

AS:np

encl.

RESEARCH DEPARTMENT • 115 INDIAN MOUND TRAIL • TAVERNIER, FL 33070 • (305) 852-5092

SUPPLEMENTARY COMMENTS ON THE GENERAL DESIGN MEMORANDUM,
"MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK, FLORIDA"

The U. S. Army Corps of Engineers project *Modified Water Deliveries to Everglades National Park, Florida*, provides an essential step for reestablishing more natural hydrological conditions in the Shark Slough basin. Research over the last 20-25 years indicates that more natural flow regimes for areas in Water Conservation Area 3 and northeast Shark Slough are essential for the restoration of the vegetative and wildlife communities of Everglades National Park.

The U. S. Army Corps of Engineers (COE) has undertaken this project at the joint request of the South Florida Water Management District (SFWMD) and the National Park Service (NPS). This effort represents a nationally significant initiative to restore vast areas of damaged wetlands. If properly accomplished, the project will reverse present downward trends in wildlife, and provide evidence that the Everglades ecosystem can be managed in perpetuity for all its species.

Under natural hydrologic conditions, the slow surface water flow rates in the Everglades marshes attenuated the discharge spikes that are common under current water management, and produced more gradual flow increases and longer recession periods. This caused much of the wet season rainfall in the upstream wetlands to reach the Shark Slough basin during the following dry season. The proposed structural modifications by themselves do not fully restore the natural flow pattern, primarily because excess wet season rainfall is rapidly routed through the upstream canal system into Water Conservation

AMERICANS COMMITTED TO CONSERVATION

Area 3A. Reestablishment of dry season lag flows may be the single most important step to lengthening hydroperiods in the central and lower Shark Slough and to recovering the ecological vitality of the southern Everglades. We understand that there are also serious flow problems in the current rainfall-driven formula. The recommended structural plan is designed to allow for maximum flexibility during the development of an optimum water delivery plan for the Shark Slough basin. Thus, it must be recognized that none of the alternative water delivery scenarios thus far developed for evaluation purposes for this project represent the levels of restoration and wildlife benefits that can be expected.

Upon completion of this project, the appropriate quantity, distribution, and timing of water deliveries and the resulting response of the system to these changes can then be determined by an iterative testing process. We agree with the COE that a long-term program of iterative field tests in conjunction with an environmental monitoring program is the best approach to developing optimum water delivery formulas for the Park.

To achieve the optimal alternative for restoring flow into the Shark Slough basin, the project must include funding for intense monitoring of the response of flora and fauna to the hydrological changes, with monitoring strategies that emphasize rare and endangered species. The monitoring program should (1) begin while the project structures are under construction and cover all areas affected by the project. Such a monitoring program will provide much information that will guide each water management action, assure the safety of endangered species, and provide major opportunities for public education projects on wetland function, management, and preservation.

At the same time there must be a process instituted to resolve the possible conflicts between the U.S. Fish and Wildlife Service (FWS), in their lead role in protecting Endangered Species (under the Endangered Species Act), and NPS's congressional requirement to restore the East Everglades (Everglades National Park Protection and Expansion Act of 1989). Differences between the agencies regarding a preferred delivery schedule are in large part due to differences in the accuracy of wildlife assessment techniques. The National Audubon Society (Society) concurs with the Corps that the

RESPONSES TO

National Audubon Society — Letter of January 4, 1991

1. Funding for the monitoring of the flora and fauna within ENP would be addressed under the budgetary process of the Department of the Interior. Funding and monitoring in WCA No. 3 and Big Cypress National Preserve could be conducted by the SFWMD and the FGFWFC as a continuation of the Systematic Reconnaissance Flights study. This study has gathered ecological information in those area for the past five years. A commitment will be sought from these agencies to continue their funding and involvement in the regional effort.

wildlife evaluation models used thus far, and which resulted in a jeopardy opinion for the Basic Rain-Driven alternative, have produced predictions of wildlife responses that are both "counter-intuitive" and in conflict with the majority of expert opinion. In order to avoid further disagreements, the Society suggests that a coordination process be established for reaching a consensus on the wildlife assessment techniques that will be used for evaluating future operational schedule proposals. The Society is concerned that water management actions taken solely to benefit one species will be detrimental to other species in the ecosystem (including endangered species). A piecemeal approach of habitat improvements for single species will hinder basin-wide restoration efforts.

(2)

COMMENTS ON THE PREFERRED WATER DELIVERY ALTERNATIVE

The results of detailed analyses conducted by the National Park Service show that, of the four water delivery alternatives, the rainfall-based delivery plan (such as the Basic Rain-Driven or Modified Rain-Driven alternatives) is the best approach for reestablishing more natural hydrological conditions in the Shark Slough basin. Of the two rainfall driven approaches, the Basic Rain-Driven alternative should provide the greatest restoration of natural flow timing, seasonal variability and distribution, and may be the most successful alternative for mitigating large regulatory releases into the Shark Slough basin.

The Modified Rain-Driven alternative may achieve similar beneficial water depth and hydroperiod increases, but these increases would be in response to much higher regulatory flows. Under this alternative, Park inflows would respond more to upstream water management than to local rainfall, which does not represent a restoration of more natural hydrologic conditions.

The two rainfall driven alternatives appear to be more successful in reestablishing longer hydroperiods in central Shark Slough, and in providing at least a partial restoration of surface water to the adjacent higher marshes in the East Everglades. Park scientists consider that shortened hydroperiods throughout these wetlands during the 1960's and 1970's, are the primary reason for the sharp reductions in

2. See response to comment #4 in Dr. Frederick's letter (page F-8).

alligators and the collapse of early dry season foraging areas for wading birds (Ogden et al. 1988, Johnson and Ogden 1990).

The Johnson and Ogden report (1990) also shows that neither of the two rainfall driven alternatives, as presently configured, reproduces the natural lag in dry season flows expected in the natural system, and that both would increase the frequency of complete drydowns in the central slough, as compared to a natural system simulation model. The loss of persistent flows and the resulting reduction of freshwater pools in the central slough and coastal mangrove zone are thought to be major factors causing the overall declines in the systems aquatic productivity, and prompting abandonment of the historical wading bird nesting areas of Everglades National Park.

The Base and Modified Base alternatives would provide essentially no restoration of natural flow timing, seasonal variability, or restoration of natural flow distributions. These alternatives also would produce more destructive "regulatory releases" because of their strict adherence to the fixed monthly delivery allocations of the Minimum Delivery Schedule, and their inability to divert flows into WCA 3B or Northeast Shark Slough (see pages 23-31, Johnson and Ogden 1990). Large regulatory releases under the Minimum Delivery Schedule during the wet season are a primary factor contributing to increased alligator nest flooding and reduced alligator nesting success in the wetlands downstream of the S-12 structures in western Shark Slough. Similar unseasonal regulatory releases during the dry season have been blamed for the disruption in the natural drydown cycles of Shark Slough, making the area less suitable to foraging wading birds (Ogden et al. 1988).

The Base and Modified Base alternatives would hold too much surface water within the lower end of Water Conservation Area 3A, producing seasonally unnatural foraging habitat for wading birds, and rendering the area less suitable as nesting habitat for alligators (see pages 58-62, Johnson and Ogden 1990). This is consistent with the findings of the systematic reconnaissance surveys conducted in the Water Conservation Areas by the National Audubon Society. We concluded that the deeper sloughs at the southern end of WCA 3A are not available to the shorter-legged waders until the late dry season, or during more severe droughts (Bancroft, Hoffman and Sawicki 1987, and Hoffman, Sawicki, and Bancroft 1988, and 1989).

Major and frequent drydowns in Northeast Shark Slough such as those proposed under the Base and Modified Base alternatives would have adverse impacts on overall aquatic productivity. Sampling by Park researchers has shown that the mean number of fishes in western Shark Slough ranged between 11 and 25 per square meter (Loftus et al. 1986). In contrast, mean numbers of fishes in the over-drained marshes of Northeast Shark Slough ranged between 1 and 4 per square meter. In addition, J. Browder (pers. comm) has reported that shortened hydroperiods in Everglades marshes significantly alter the species composition of the periphyton community, thus altering the food base for aquatic invertebrates and small fishes. The inability of the two Minimum Delivery alternatives to restore water depths and hydroperiods in the historical eastern flowway of Northeast Shark Slough is due to the requirement of passing all surface water flows through the S-12 structures, and an overall reduction of water deliveries to Shark Slough. The Park report shows that under actual conditions, Shark Slough received an annual average of 610,000 acre-feet during the 14-year test period (USGS published data). In contrast, the Base and Modified Base alternatives would reduce average annual inflows by approximately 138,000 acre-feet, and would produce the driest downstream conditions of the proposed alternatives (pages 34-48).

Restoring Surface Water Flows to WCA 3B

Construction of the L-29 and L-67A-C levees blocked the natural sheetflow across the marshes into Shark Slough and WCA 3B, and produced an artificial impoundment of surface water in southern WCA 3A. All of these changes have altered vegetative communities and available wildlife habitat in WCA 3A (Zaffke 1983). Examination by the Park staff of the modeled average water depth conditions at stations 3A-28 and 3B-29 in the southern portions of WCA 3A and 3B, respectively, support this conclusion (see Figures 25 and 26, Johnson and Ogden 1990). For example, under the Base alternative, water depths are approximately 1.5 feet greater in WCA 3A than in WCA 3B. Thus levee construction has produced an artificial lengthening of hydroperiods in WCA 3A and shortened hydroperiods and promoted unnatural drydowns in WCA 3B (R. Johnson, pers. comm.).

Relatively little information exists on the aquatic productivity of the WCA 3B marshes. A study of wading bird nesting success in the Southern Everglades, conducted by the Florida Cooperative Fish and Wildlife Research Unit, noted that between 1986 and 1987 only 6 to 12 percent of the overall wading bird nesting attempts in Water Conservation Area 3 occurred within the shorter hydroperiod marshes of WCA 3B (Frederick and Collopy 1988). The authors speculate that this pattern was in response to slower drying rates and unseasonal water level rises. These unfavorable hydrologic conditions are presumably a result of the isolated nature of this basin. Aerial survey data collected by the National Audubon Society research staff, on numbers of feeding wading birds in WCA 3A and 3B for the period December 1986 - August 1989, show fewer wading birds in WCA 3B than in 3A in proportion to the area of each, during 20 of 24 survey months (Bancroft et al. 1987, Hoffman et al. 1988, 1989). In all three years, 1987-1989, the Audubon data show the relatively lower elevation marshes in southern WCA 3B to have been drier late in the dry season than marshes in southern WCA 3A. The proposed construction of the S-345 structures appear to be the best method of restoring more natural hydroperiods by reestablishing surface water flows from WCA 3A into WCA 3B. Similarly, under high water conditions, the diversion of surface water from WCA 3A to WCA 3B will reduce the detrimental impacts of large regulatory releases through the S-12 structures by spreading these flows (3) over as large an area as possible. The COE should investigate the potential of spacing the S-345 structures more uniformly along the L-67A canal. This would help the restoration efforts by distributing flows from 3A into 3B over a wider front which would better mimic natural sheetflow.

Reducing Flows Down the L-67A Canal

The draft GDM correctly states that the primary purpose of the S-349 structures is to reduce southward (4) canal flow thereby inducing overland flow through the WCA 3A marsh. We consider the reestablishment of more natural sheetflow to the Park water delivery structures as the most beneficial element of the overall structural plan. Several additional benefits would also be derived from reducing L-67A canal flows:

3. Further evaluations made by the Corps of Engineers since publication of the Draft GDM, have resulted in spacing the S-345's over three miles apart instead of the originally proposed 6,000 feet. This change will be reflected in the revised version of the GDM.

4. Both BRD and MRD would include operational criteria for the S-349 structures in the L-67A borrow canal.

1. More water would be held back in the northern marshes of WCA 3A improving overall surface water distribution patterns.

2. Damaging regulatory releases through the S-12 and S-333 structures would be reduced by producing more gradual sheetflow through the marsh.

3. The quality of S-12 and S-333 water deliveries would be improved by increased marsh residence times.

4. The S-349 structures would raise water levels upstream of the S-345 structures thereby increasing flows from WCA 3A into WCA 3B.

During high water conditions such as those of 1969 and 1970, blocking flows down the L-67A canal by closing the S-349 structures (as proposed under the Basic Rain-Driven alternative) would increase the total annual diversions from WCA 3A through the S-345 structures into WCA 3B by 375,000 and 440,000 acre-feet, respectively (Johnson and Ogden 1990). This would greatly reduce the damaging impacts that large regulatory releases through the S-12 structures have on wildlife in the Park by distributing excess water over the largest area possible.

Since the implementation of the current experimental water delivery program, dry season deliveries to the South Dade Conveyance System have been shifted away from the L-67A canal to the L-30 canal system. If this approach continues, the need for large operational spillways such as the proposed S-349 structures could be reduced. We would recommend that the COE investigate alternatives such as the implementation of fixed earthen structures (such as the current G-211 structure under construction in the L-31N canal). This would substantially reduce the project's overall cost. Any loss of conveyance through the S-345 structures caused by these modifications could be offset by increasing the number of S-345 structures.

5. The feasibility of using culvert structures similar to the G-211 in the L-31N canal is being investigated as a cost saving measure. Resolution of this issue would be resolved in the FDM that includes these structures.

Reestablishing Flows between WCA 3B and Northeast Shark Slough

The proposed S-355 structures would allow surface water flows to pass from WCA 3B into the L-29 canal and then directly into Northeast Shark Slough following a rainfall-runoff relationship similar to the existing formula. On an annual basis, approximately 51 percent of the deliveries to Northeast Shark Slough would pass through the S-355 structures (Table 8 in the GDM should be corrected to reflect losses through S-334 to the South Dade Conveyance System). We concur with a recent park recommendation (R. Johnson, pers. comm.) that the COE examine the potential of increasing this percentage to approximately 75 percent. Allowing a larger percentage of the water deliveries to Northeast Shark Slough to pass through the WCA 3B marshes increases the overall marsh residence times, thereby restoring more gradual flow increases and prolonged recession periods. This would help to reestablish more natural dry season lag flows, and allow deliveries to fluctuate more in response to rainfall and upstream antecedent conditions. Reestablishment of dry season lag flows may be the single most important step to lengthening hydroperiods in the central and lower Shark Slough and to recovering the ecological vitality of the southern Everglades.

(6)

Simply enlarging the existing S-333 structure and not constructing the S-345 and S-349 structures (as has been recommended by the FWS and other groups) will continue the practice of rapidly routing canal flows down the L-67A canal and into Shark Slough. This would provide for increased delivery volumes but would not mitigate the effects of upstream regulatory releases, nor allow the timing of flows to respond more naturally to upstream rainfall. Similarly, the important benefits of increased residence time of flows through the WCA 3B marshes would be lost with this restricted approach, as would the beneficial improvements in hydrologic conditions in WCA 3B in response to increased hydroperiods.

Under the proposed operations criteria, persistent flows through the S-355 structures would have occurred throughout all of the test years under the two rain-driven alternatives. The Society is concerned that allowing surface waters to be continuously drained from WCA 3B without offsetting

6. Providing 55 percent of the total flows to NESRS is a goal of the project that was based on rough estimates of historic flow distribution. The structural capacity is not adequate to accomplish this goal at all times. During future operational studies/coordination, increasing the target distribution to a 25/75 split between SRS and NESRS can be evaluated.

WCA 3B inflows will lead to over-drainage of the wetlands in 3B. This will reduce the ability to increase hydroperiods and improve overall habitat conditions in the marshes of WCA 3B. Review of the average water levels at the 3B-29 recorder in the southern portion of WCA 3B (Figures E-101 and E-102 in the draft GDM) clearly shows that relatively modest stage increases would occur under the two rain-driven alternatives. Water level increases ranged from less than 0.1 feet during dry season to just over 0.4 feet during the wet season. Restoration of these long hydroperiod marshes requires the maintenance of higher water level conditions, particularly during the dry season. We recommend that the operations criteria be reviewed to determine if increasing S-345 inflows to balance S-355 outflows is feasible.

7

CONFLICTING VIEWS WITHIN THE DEPARTMENT OF THE INTERIOR

The National Audubon Society recognizes that the conclusions and recommendations presented herein, and in Johnson and Ogden (1990) conflict with the views of the U. S. Fish and Wildlife Service. The most important of those differences deal with the role of Water Conservation Areas 3A and 3B in the Park's restoration efforts, and the potential wildlife benefits expected under the four proposed alternatives. It is the Society's view that a return to more natural hydrological conditions must occur in the wetlands immediately upstream of the Park boundary (WCA-3) in order to reestablish natural patterns of marsh-flow into the Park.

Restoration of more natural hydrologic conditions in WCA 3A and 3B (as proposed under the two rainfall driven alternatives) will also provide improved seasonal habitat for wildlife populations that move freely across the Park's boundary (see pages 71-72, 86-87, and 96-97, Johnson and Ogden 1990). In their report on the reproductive ecology of wading birds in the Everglades, Frederick and Collopy (1988) stated that "the rainfall driven release program (which is the delivery formula followed under the Basic Rain-Driven alternative) appears more desirable than the earlier schedule (the Minimum Delivery Schedule followed under the Base and Modified Base alternatives), and some combination of structural modifications to complement the rainfall driven program appear very much more beneficial".

7. Modelling of the S-355's operational criteria includes several conditions that prevent overdraining of WCA No. 3B. Due to losses in the system, inflows to the area are greater than outflows. This can be seen on the tables in the GDM. However, this issue would be addressed in detail during the iterative testing period.

It is our recommendation that any continuing examination of the relative merits of alternative delivery schedules for ecosystem and wildlife restoration should exclude any consideration of the Modified Base alternative. The Park has fully evaluated this option, and has concluded that, because of its structural and operational limitations, this alternative does not have the potential for meeting the restoration goals of this project.

We agree with the Fish and Wildlife Service regarding their concern that adequate volumes of water must be available for our restoration efforts to be successful. We also concur that the Park needs to more clearly identify the long-term water delivery volume requirements before an improved delivery option can developed. The Park is currently working jointly with the SFWMD on several avenues of research to address these issues, but no real progress can be made until the correct placement and timing of water is achieved by this project.

We cannot agree that WCA 3B is currently in good ecological condition, or that flows through WCA 3B are not needed for the Park's restoration program. The above discussions point out the unnatural water depth distributions that occur between WCA 3A and 3B, and the fact that this has led to reductions in overall hydroperiods in WCA 3B. Current studies designed at estimating the natural hydrologic conditions through the Everglades similarly indicate that these reduced water depths and shortened hydroperiods are in response to man-induced changes (MacVicar and Johnson, Everglades Symposium, October 1989). Recent studies of wading bird nesting patterns in the conservation areas indicate that WCA 3B has a disproportionately lower percentage of overall nesting attempts than would be expected, when compared to WCA 3A (Frederick and Collopy 1988). As stated earlier, the authors believed that this was a response to detrimental hydrologic conditions in the basin.

(8)

The solution for resolving the conflicting habitat requirements of Everglades wildlife, including habitat requirements (sometimes conflicting) of several endangered species, is through an ecosystem approach. Management for ecosystem recovery in the Park and all remaining wetlands in the Everglades region provide the greatest assurance that endangered species will survive within the system over the long-term.

8. There are numerous references throughout the document stating the view that ecological and hydrologic restoration of WCA 3B is needed in order to restore the Park.

Differences between the agencies regarding a preferred delivery schedule should not be viewed as an immediate impediment to the restoration program. The National Audubon Society supports the recommendation contained in the GDM, which calls for all appropriate agencies to develop an improved delivery schedule during the project construction period. This approach will provide additional time to resolve the problems with wildlife assessment techniques used and to address the concern regarding adequate volumes of water in order to meet the restoration goals.

SPECIFIC COMMENTS ON THE DRAFT E.I.S.

(9) Summary. p. vii. 1st paragraph. We suggest that the final sentence in this paragraph be re-written to read: "Despite Congressional actions in 1970 establishing a minimum monthly schedule of water deliveries through the S-12 structures, the Park experienced ecological decline at an accelerated pace."

(10) Summary. p. viii. Section 4. We strongly agree that the only realistic option for achieving ecological restoration in the Park is through "... an evolutionary and dynamic process requiring many years of iterative field testing of water delivery strategies in conjunction with an environmental monitoring program..." No existing models are accurate enough in their hydrological and ecological databases to serve as a substitute for a real-world field testing and evaluation process. The proposed environmental monitoring program must be conducted both within the park and in the adjacent and upstream wetlands including WCA 3.

(11) Summary. p. ix. Section 7. The National Audubon Society concurs with the National Park Service that the existing evaluation models used by the FWS for the Wood Stork and the American Alligator do not accurately predict responses by these two key species to the delivery alternatives. In both cases, the models do not address the correct environmental factors nor utilize the correct tolerance limits for the environmental factors that are used.

9. The DEIS has been revised to reflect the comment.

10. See response to comment #4 in Dr. Frederick's letter (page F-8).

11. This issue is moot for the GDM decision because other factors were used in selecting the operational strategy being recommended.

Summary. p. ix. Section 10. The Society supports the Corps review of the Biological Opinion, and will assist where possible in providing information required by the Corps for determining the need for reconsultation. We, and others, view the jeopardy opinion on the Basic Rain-Driven schedule to be unsupportable under peer review; nevertheless, it represents a potential threat to the continuation of the Experimental Water Delivery Program. Our assessment, and that of a majority of "kite experts," is that the Basic Rain-Driven schedule does not create a jeopardy condition for the Snail Kite. (12)

Page EIS-1. The Park's restoration goals, as stated in Johnson and Ogden (1990), are as follows: (13)

1. Allow the volume and timing of surface water flows through the Water Conservation Areas and Everglades National Park to fluctuate naturally in response to rainfall and antecedent hydrologic conditions.

2. Restore more natural surface water flow patterns within Water Conservation Areas 3A and 3B and return to pre-project flow distributions across the entire width of the Shark Slough Basin.

3. Mitigate the detrimental downstream effects of large regulatory releases into western Shark Slough by diverting excess stormwater as sheet-flow from WCA 3A into WCA 3B and Northeast Shark Slough.

4. Restore surface water depths and hydropatterns throughout the southern Everglades as much as possible, to correspond with the natural soil and topographic conditions found in each basin.

5. Improve and maintain the quality of waters flowing through the southern Everglades, so that the natural resources of the area are not altered or degraded.

12. See response to comment #1 in SFWMD letter (page F-36).

13. The referenced DEIS text lists 5 of the 7 restoration goals originally presented by the Park to the SFWMD's Governing Board in March of 1983 and subsequently by letter to the Corps. Action has already been taken on the other two. These 5 goals were incorporated into the Corps planning process from the beginning. The list of goals provided in the comment are recent refinements of the original, and are consistent with them.

(14) Page EIS-4. Section 2.06. In the absence of better data on Snail Kite refugia, we expect there will be problems agreeing on the minimum area required for a refugia in 3A.

(15) Page EIS-9. Section 3.03. The Shark Slough is only the southern, constricted portion of the Everglades, and does not extend north to Lake Okeechobee. The three sources of water listed are for the Shark Slough in the Park, not for the entire Park.

(16) Page EIS-17. Section 3.20. WCA 3A may also be less suitable for nesting wading birds because of a relatively high frequency of unseasonable water level fluctuations that are due to other water management priorities.

(17) Page EIS-17. Section 3.21. A drying rate value of 0.08 inches per day as a requirement for "good nesting years" for wading birds is an overly simplistic and dangerous concept. No such constant relationship exists. Long-term declines in fishes in the marshes, due to chronic problems of unnaturally shortened hydroperiods, has resulted in a situation where increasingly more rapid and extensive drying is required to produce the fish densities that are necessary to support nesting wading birds.

(18) Page EIS-18. Section 3.24. Critical habitat is an all or nothing legal concept. Thus, both WCA 3A and portions of Shark Slough are critical habitat equally!

(19) Page EIS-22. Section 4.05. The National Park Service's wildlife analyses (based on years of research, including the systematic reconnaissance flight project and years of Wood Stork studies) also disagreed for Wood Storks and American Alligators.

(20) Page EIS-22. Section 4.07. Ecological restoration of WCA 3B and the Northeast Shark Slough are believed to be key to restoring wading bird populations.

14. In their Biological Opinion, the USFWS has defined the number of Hydrologic Model grid cells that would provide the requisite drought refuge in WCA 3A.

15. The DEIS has been revised to reflect the comment.

16. The DEIS has been revised to reflect the comment.

17. The DEIS has been revised to reflect the comment.

18. The DEIS has been revised to reflect the comment.

19. The referenced paragraph is accurate as it stands. The issue is further elaborated on in DEIS paragraph 4.16 and displayed numerically in Table 7 of the DEIS.

20. This is so stated in several locations in the report.

(21) Page EIS-25. Sections 4.16 and 4.17. The Park's analyses show either of the two rain-driven alternatives as being superior for the Wood Stork, than the Modified Base alternative. More extensive flooding in the Northeast Shark Slough, as is shown for the Modified Rain-Driven, would actually benefit the stork by improving the regional food base. The incorrect conclusions obtained by the FWS for the Wood Stork were caused by the failure of their model to consider the environmental variables that regulate the stork populations in the Park: the longer hydroperiods required to produce higher prey biomass during the period of traditional colony formation.

Page EIS-27. Section 4.23. The National Audubon Society agrees that a major, unresolved question for future water delivery plans is the question of the volume of water required for restoration. The delivery alternatives and structural proposals under current review focus more on timing and distribution of flows than on volumes. When appropriate distribution and timing can be achieved, as a result of this project, the question of quantity can be profitably addressed.

(22) Page EIS-29. Section 4.26. The Park's assessment shows the Modified Base alternative to be less likely to benefit the stork and kite than will a rainfall-based plan. The Park's assessment has shown that, because a greater area of surface water would be retained in 3A for a longer period with the Basic Rain-Driven alternative, a greater portion of the Snail Kite population would be retained longer in 3A for each dry season of the evaluation period. In addition, high mortality by dispersing Snail Kites has not been demonstrated. Certainly the more rapid or extensive drying in the Northeast Shark Slough, shown for the Modified Base alternative, would be detrimental, not beneficial, to the stork, by reducing overall fish production in this region.

(23) A recent collapse in the number of Snail Kites in WCA 3A, from 166 in Dec 1989 to 13 in Dec 1990 (J. Rodgers, pers. comm.) demonstrates that managing WCA 3A as a kite refugia almost certainly will not work. Other hydrological considerations will always take precedence over kite requirements in WCA 3A, and thus the FWS would do well to look for more realistic options for maintaining a viable kite population in south Florida. A regional Everglades restoration program would seem to us to be

21. Information from the Park included in the Fish and Wildlife Coordination Act Report indicated that the MMD plan was superior for wading bird colony nesting success (DEIS Table 7). Analysis for the wood stork was not presented separately. As stated above, the issues involving wildlife evaluations are moot for the GDM process.

22. The relationship between dispersal and mortality in snail kites is poorly understood. Field studies could be useful to address this data gap.

23. It is recognized in the USFWS Biological Opinion that there will be times when it is not possible to maintain standing water in WCA 3A even with supplemental water releases and cut-backs. These measures were not applied during the cited period, but the depth of the recent drought would have almost certainly made them ineffective. The intent is to make such occurrences less frequent.

a more likely solution, in that it would result in the reestablishment of longer hydroperiod conditions in portions of the ecosystem where these conditions naturally occurred. The Society suggests that suitable kite habitat is more likely to survive in areas where the combined affects of topography (lower elevations) and a higher priority for ecosystem management (the Park and Loxahatchee, N.W.R., for example) are likely to work in unison to maintain the necessary long-hydroperiod conditions.

(24) Page EIS-38. Section 4.57. The Society agrees that restoration of the Northeast Shark Slough and the main Shark Slough will <u>require</u> that more natural hydrological conditions be established in WCA 3B. Page EIS-45. Table 3. The correct ranking of Wood Stork seasonal feeding habitat would be: 1. Modified Rain-Driven, 2. Basic Rain-Driven, 3. Modified Base, 4. No-action (Johnson and Ogden 1990). The same ranking would apply for the Wood Stork population recovery. The Park's analyses also show the Basic Rain-Driven alternative to be superior to the Modified Base alternative for the Snail Kite.

We appreciate this opportunity to further comment and to indicate our support for this project.

Alexander Sprunt IV
Vice President for Special Projects
National Audubon Society

January 1991

24. The cited DEIS Table 3. was based on the information presented in DEIS Table 7. As such, the ranking is correct as shown.

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ER 90/715

FEB 5 1991

Mr. A. J. Salem
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Dear Mr. Salem:

The Department of the Interior has reviewed the general design memorandum and draft environmental impact statement for Modified Water Deliveries to Everglades National Park. We have the following comments and recommendations.

The Department of the Interior (Department) supports the recommendation contained in the draft GDM, which calls for all appropriate agencies to develop an improved delivery schedule during the project construction period. This approach will provide additional time to resolve the problems with wildlife assessment techniques used and to address the concern regarding adequate volumes of water in order to meet the restoration goals. The Department concurs with the Corps recommendation that the delivery system would be operated according to the Modified Rain-Driven plan in the event that no improved water delivery schedule is approved during the construction period.

The Department has reviewed the subject project and agrees it provides an essential step for the reestablishment of a more natural hydrologic regime in the Shark Slough Basin. The Corps has undertaken this project at the joint request of the South Florida Water Management District and the National Park Service. This effort represents a nationally significant initiative to restore wetlands. Because of its scope and multi-jurisdictional nature, the project will require strong support from the public and from local, State and other Federal agencies. If properly accomplished, the project may reverse present downward trends in wildlife numbers and diversity, and provide evidence that the Everglades ecosystem can be managed in perpetuity for all species.

The Department strongly supports the full structural plan as recommended in the draft GDM. The selected plan includes all of the structural features of the Basic and Modified Rain-Driven alternatives. The Department views implementation of the full structural plan as essential to restoration of the Shark Slough Basin.

Regardless of what operation schedule is initially approved, the Department feels that in order to achieve the optimal alternative for restoring flow into Shark Slough Basin and protecting threatened and endangered species, the project will require a flexible program of iterative tests. This must be coupled with funding, as a project cost, for careful monitoring of the response of the flora and fauna to the hydrological changes. Monitoring strategies must emphasize threatened and endangered species. Such a monitoring program will provide much information that will guide each water management action. The monitoring program should begin while the structures are under construction and cover all areas affected by the project. (1)

We appreciate this opportunity to comment and to indicate support for this project.

Sincerely,

Jonathan P. Deason
Director
Office of Environmental Affairs

RESPONSES TO

Department of Interior — Letter of February 5, 1991

1. The basic design of a monitoring program has been developed and is described in the revised GDM and EIS. However, further refinements will be made through a coordination and planning process. In order to develop the best possible program, a number of agencies, organizations, and universities should be involved. The Corps will work closely with the Park to define the details and responsibilities for such a program.

EIS APPENDIX G

RESPONSES TO RECOMMENDATIONS
IN
FISH AND WILDLIFE COORDINATION ACT REPORT

FINAL ENVIRONMENTAL IMPACT STATEMENT

GENERAL DESIGN MEMORANDUM-MODIFIED WATER DELIVERIES TO
EVERGLADES NATIONAL PARK

Central and Southern Florida Project
Part 1, Supplement 54

This appendix provides the Corps responses to the recommendations made by the U. S. Fish and Wildlife Service in the report of the Secretary of Interior under Section 2(b) of the Fish and Wildlife Coordination Act. The referenced recommendations (paraphrased below) appear on pages 30-32 of the report dated March 1991 (EIS Appendix D).

Recommendation 1. Structures should be built to allow redistribution of flows across the original width of Shark River Slough by passing water through WCA-3B. In addition, S-333 should be enlarged to provide additional operational flexibility.

Response. The referenced new structures are part of the recommended plan. Enlarging existing structure S-333 is not recommended because discharges to NESRS could not be significantly increased. Moreover, flows through WCA-3B would be reduced. Increased discharges through S-333 quickly raise downstream water levels in the L-29 Canal, thereby reducing the head across the structure and limiting discharges. Therefore, because of downstream flow limitations, increased capacity at S-333 would not significantly increase operational flexibility. Higher stage in the L-29 Canal would reduce discharges from WCA-3B through the proposed S-355's. L-29 Canal stages would be the same as, or higher than upstream stages more frequently. This would not be consistant with the general goal of restoring natural hydrologic conditions.

Recommendation 2. Future refinement in the operating criteria for the new structures and other components of the C&SF system must consider results from modeling, iterative testing, and monitoring.

Response. Concur.

Recommendation 3. Further planning and modeling should be undertaken by the Corps and the SFWMD in order to resolve potential conflicts over competition for water.

Response. The Corps will undertake additional planning and modeling to minimize potential water supply conflicts. However, major changes in water supply allocations or changes to the water supply system are beyond the scope of the authorization of the project.

Recommendation 4. Supplemental monitoring should be implemented to cover other portions of the southern Everglades and other ecological effects.

Response. Concur.

Additional recommendation 1. S-333 should be enlarged to add flexiblity in routng water during droughts, or add conveyance during high flow periods.

Response. See response to recommendation 1, above.

Additional recommendation 2. The Corps should reinitiate the C&SF Water Supply Study in order to identify and allocate adequate water supplies for the remaining Everglades.

Response. This study has been deauthorized.

Additional recommendation 3. Restore a portion of the historic vegetated flow-way from Lake Okeechobee to the southern Everglades to help convey regulatory releases of water from the Lake southward, remove nutrients, and smooth transitions in timing of water movement.

Response. Construction of Storm Treatment Areas 1, 2, and 3 by the SFWMD will perform these functions.